Abstracts to the Second Biennial Meeting of the International Academy of Adhesive Dentistry, June 16-17, 2017

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L01: Laboratory Research

Bond Strength of Resin Cements to CAD-CAM Resin/Ceramic Hybrid Materials

Marcelo Giannini[a]*, Eduardo Castro[a], Veber Azevedo[a], Gabriel Nima[a]

[a]Piracicaba Dental School - UNICAMP, Piracicaba, São Paolo, Brazil

Purpose: This study investigated the effect of atmospheric pressure plasma application on shear bond strength (SBS) of two resin cements to indirect restorative materials.

Materials and Methods: Three CAD-CAM resin/ceramic hybrid materials (Lava Ultimate, 3M ESPE; Enamic, Vita Zahnbabrik, and Cerasmart, GC Corp.) and one regular indirect composite (Epricord, Kuraray) were tested. Indirect restorative material plates (15x5x3 mm) were prepared and submitted to three different surface treatments (n=5): 1- control (according to the manufacturer's instructions), 2- argon plasma for 30 seconds and 3- argon plasma (30 s) + adhesive primer. Silicon molds were positioned on the treated area of indirect materials and uncured resin cements (Panavia V5, Kuraray Noritake or RelyX Ultimate, 3M ESPE) filled up the hole (1.5 mm thick and 1.5 mm in diameter) of molds. Resin cements were light activated for 20 seconds with a curing unit (Valo Cordless, Ultradent) and plates water-stored for 24 hours before SBS test. SBS data were analyzed by three-way ANOVA and Tukey's post-hoc test (a=0.05).

Results: SBS of Panavia V5 and RelyX Ultimate to Lava Ultimate following plasma and plasma + adhesive treatments yielded no significant difference when compare to control. For other indirect materials, the treatment according to the manufacturer's recommendations produced the highest SBSs of Panavia V5. RelyX Ultimate applied to Enamic followed by plasma treatment showed no significant difference when compared to control. For Cerasmart and Epricord, the application of plasma and plasma + adhesive did not differ from control too. In general, RelyX Ultimate yielded higher the SBS to indirect materials than those obtained with Panavia V5.

Conclusion: SBS of resin cements to indirect materials according to the manufacturer's instructions always showed better results, however plasma application can be an alternative surface treatment, depending on indirect material and resin cement.

Funding/Conflict of Interest: Funding: FAPESP # 2015/02461-0.

Keywords: composite resins, shear strength, plasma gases, adhesives, CAD-CAM.

L02: Laboratory Research

Adhesion of Cast Metal Alloy and Lithium Disilicate Copings Luted to Different Core Build-Up Materials with Self-Adhesive Resin Cement

Ziad Nawaf Al-Dwairi[a], Khalil Aleisa[b], Abdulhameed Al-Beshr[b], Yazeed Al-Habdan[b], Faisal Al-Harbi[b], Nadin Al-Haj Husain[c], Mutlu Özkan[c]*

[a]Jordan University of Science and Technology, Irbid, Jordan
[b]King Saudi University, Riyadh, Saudi Arabia
[c]University of Zurich, Zurich, Switzerland

Purpose: This study evaluated the shear bond strength of two coping materials (non-nickel chrome-based cast alloy and lithium disilicate ceramic (IPS Empress) to four different core foundation materials (resin composite, cast metal alloy, lithium disilicate, and dentin), luted with adhesive resin cement (RelyX Unicem).

Materials and Methods: Specimens (N = 56) were fabricated and divided into eight groups (n = 7 per group). Each coping material was luted with self-adhesive resin cement (RelyX Unicem) to the core materials. Bond strength was measured in a Universal Testing Machine (0.5 mm/min). Data were statistically analyzed using a two-way analysis of variance (ANOVA) and Tukey's HSD tests (alpha = 0.05).

Results: Both core (p = 0.000) and coping material type (p = 0.000) significantly affected the mean bond strength (MPa) values. Interaction terms were also significant (p = 0.001). The highest bond strength results were obtained when lithium disilicate was bonded to lithium disilicate (21.48) with the resin cement tested. Lithium disilicate in general presented the highest bond results when bonded to all core materials tested (16.55–21.38) except dentin (3.56). Both cast alloy (2.9) and lithium disilicate (3.56) presented the lowest bond results on dentin followed by cast-alloy-cast alloy combination (3.82).

Conclusion: When self-adhesive resin cement (RelyX Unicem) is chosen for luting coping material to core material, the choice of material should be lithium disilicate for both the coping and the core, which should be etched with hydrofluoric acid for 1 min prior to bonding. RelyX Unicem cannot be indicated for bonding coping materials on dentin due to low bond strengths obtained.
Funding/Conflict of Interest: None.

Keywords: adhesion, cast metal, lithium disilicate, resin cement

L03: Laboratory Research

Evaluation of Bonding Durability of G-CEM LinkForce to As-Press Surface of Ceramics

Hiroaki Kakinuma[a]*, Naofumi Matsumoto[a], Akishi Arita[a], Tomohiro Kumagai[a]

[a]GC Corporation, Tokyo, Japan

Purpose: Clinically, the demand of ceramics restoration is increasing because of their excellent cosmetic property. Therefore, there are many studies of bond-strength to press ceramics. However, these are not completely reflected about the real clinical case because the reaction layer remains on as-press surface of ceramics and is not polished clean. It may be widely different from test conditions. This time, we launched new products, press ceramics “Initial LiSi Press” and resin cement “G-CEM LinkForce”. In this study, we evaluated the effect of bonding durability to as-press surface of ceramics.

Materials and Methods: The bonding durability was measured by tensile-bond test according to each company’s system, GC corp. vs Ivoclar Vivadent corp. GC’s system includes “Initial LiSi Press”, “Initial LiSi Press Vest” and “G-CEM LinkForce”. Ivoclar’s system includes “IPS e.max Press”, “IPS Press VEST Speed” and “Multilink Automix”. There were 3 test groups different from surface treatment, as-press surface of ceramics without treatment (N), treated with phosphoric acid 37% after divesting (P) and treated with hydrofluoric acid 5% after divesting (F). One of the specimen groups was subjected to thermo-cycling (5-55 ℃, 5000 times), the other was not. Tensile-Bond tests were performed each test group (crosshead speed; 1 mm/min.) (n=10).

Results: In the evaluation of bond testing, the bond strength in GC’s system was significantly increased after surface treatment (F, P) ($p < 0.05$; Table 1). In the Ivoclar’s system, there was NOT significant increase. From measurement of X-ray diffraction (XRD) and Scanning Electron Microscope (SEM, Figure 1), there was few reaction layer on the ceramics surface in GC’s system. It is considered that the effect of the surface treatment is easily obtained and the bond strength was further improved.

	G-CEM LinkForce			Multilink Automix		
	Initial LiSi Press			IPS e.max Press		
[MPa]	N	P	F	N	P	F
TC0	19.9 (±3.9)^{C}	30.9 (±5.6)^{AB}	34.3 (±6.6)^{A}	20.1 (±4.8)^{C}	25.6 (±6.2)^{B,C}	26.0 (±5.3)^{B,C}
TC5000	21.5 (±5.0)^{b}	35.3 (±4.9)^{a}	34.1 (±3.7)^{a}	18.4 (±6.7)^{b}	24.9 (±5.3)^{b}	23.4 (±3.4)^{b}

Table 1: Tensile bond strength values

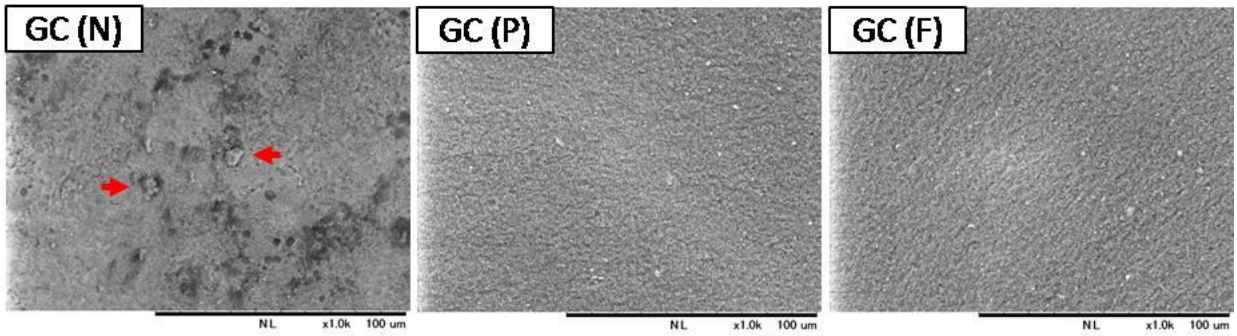

Figure 1: SEM pictures

Conclusion: G-CEM LinkForce has excellent bonding durability to Initial LiSi Press. It is indicated that because the reaction layer on as-press surface can be easily removed and hardly remain by simple pre-treatment in GC's system.

Funding/Conflict of Interest: All authors are employees of GC Corporation.

Keywords: resin cement, ceramics, adhesion, bonding, as-press

L04: Laboratory Research

Universal Adhesives as Primers for Zirconia Ceramics

Huaibing Liu[a]*, Marnita Waller[a]

[a]Dentsply Sirona, Milford, DE, USA

Purpose: This study was conducted to evaluate bonding performance of universal adhesives as primers for zirconia ceramics.

Materials and Methods: Three universal adhesives were selected: Prime&Bond active (PBA, Dentsply Sirona), Prime&Bond elect (PBE, Dentsply Sirona), Scotchbond Universal (SBU, 3M ESPE); Monobond Plus (MBP, Ivoclar Vivadent) was used as control. Respective cements include Calibra Ceram (CC), RelyX Ultimate (RU) and Multilink Automix (MA). Surface of Cercon Zirconia was conditioned as follows: Surface was sandblasted with 50 mm Al_2O_3 particles for 10 seconds with Micro Etcher at distance of 10 mm with a 90° angle of the nozzle to the surface. It was rinsed, ultrasonically cleaned and dried with compressed air. Stainless steel rods (3.17 mm in diameter) were sandblasted, ultrasonically cleaned and dried. An adhesive or primer was applied to zirconia substrate and dried. Cement was applied to surface of steel rod and placed onto zirconia surface and allowed to self-cure under load. Specimens were stored in 37 °C water for 24-hr. Half of the specimens were thermocycled 10000 times (TC10000) between 5 °C and 55 °C. Shear bond strength (SBS) was obtained with Instron 3366 at a crosshead speed of 1 mm/min. The data was analyzed with ANOVA ($n=6$, $p<0.05$, Fisher test).

Results: Mean values for SBS in MPa with standard deviations are listed on the table below. After accelerated aging, three adhesives exhibited bond strength at least similar to the control, with PBA and PBE significantly higher.

Adhesive	PBA	PBE	SBU	MBP
Cement	CC	CC	RU	MA
24hr	28.7(3.8)Aa	24.1(3.7)Ba	27.0(1.7)ABa	29.4(2.6)Aa
TC10000	21.5(3.8)Ab	22.1(3.5)Aa	19.5(4.7)ABb	15.6(6.8)Bb

Within the same row, groups connected by the same upper case letter are not significantly different. Within the same column, groups connected by the same lower case letter are not significantly different.

Table 1: Shear bond strength values

Conclusion: Within limitation of this study, universal adhesives provide viable alternatives to dedicated zirconia primers.

Funding/Conflict of Interest: All authors are employed with Dentsply Sirona, whose products are evaluated and discussed.

Keywords: adhesives, cementation

L05: Laboratory Research

Different Silane Treatments on Bond Strength of Indirect Resin Restorations

Inês Caetano Santos[a], António Delgado[a], João Rua[a], Paulo Monteiro[a], Mário Polido[a], José João Mendes[a]

[a]Instituto Superior de Ciências da Saúde Egas Moniz, Caparica, Portugal

Purpose: To evaluate the microtensile bond strength of different clinical methods of silane application as a surface treatment for bonding indirect resin composite.

Materials and Methods: Nine teeth were randomly allocated to three groups according to silane treatment (n=3), S1 (silane with heat treatment), S2 (silane without heat treatment) and S3 (no silane). Each sample was sectioned by the middle dentin, submitted to immediate dentin sealing, and sandblasted with 27 mm particles for 10 seconds as an additional surface treatment. Nine resin disks of Filtek Supreme (3M ESPE) were made to simulate indirect restorations, surface treatments were performed on the disks, including Silane Coupling Agent (3M ESPE) application for 1 minute in groups S1 and S2. On the first group the silane application was followed by heating up to 100 ºC, calibrated with a thermometer, inside a vacuum machine for 1 minute. After surface treatments each disk was bonded and luted to each sample with pre-heated resin Z100 MP Restorative (3M ESPE). After 24 hour storage the samples were then sectioned to obtain a total of 142 bonded sticks (1 mm^2) submitted to microtensile testing in a universal testing machine (mTBS; 0,5 mm/min). After testing, the fractured sticks were evaluated under an optical microscope and classified according to their mode of failure. Statistical analysis was performed with ANOVA one-way and post-hoc $p \leq 0,05$ tests (SPSS 20.0).

Results: Different silane application methods yielded statistically significant differences. The subgroup where silane was heated to 100 ºC and applied (S1) obtained the highest bond strength values (43,27 MPa), statistically significant when compared to the group where silane was not used. This group obtained the lowest bond strength values of all groups (33,12 MPa).

Conclusion: Use of silane as a surface treatment method and its application method seems to be clinically relevant towards the indirect restoration's overall bond strength.

Funding/Conflict of Interest: None.

Keywords: adhesives, dentin-bonding agents

L06: Laboratory Research, Student Scientist

Surface Roughening of Titanium-based Abutment Improved Retention to Zirconia Crowns

Yuko Otsubo[a]*, Edward Chaoho Chien[a], Yuwei Fan[a], Dick Pober[a], Hideo Yamamoto[a], Dan Nathanson[a]

[a]Henry M. Goldman School of Dental Medicine, Boston University, Boston, MA, USA

Purpose: The objective of this in vitro study is to evaluate the abrasion effect of airborne particles on pull-out vertical retention of Y-TZP crown (Zenostar, Ivoclar-Vivadent) bonded to two different heights of titanium-based implant abutments.

Materials and Methods: Twenty titanium-based abutments (Variobase, Straumann), A. 3.5mm in height (n=10) and B. 5.5mm in height (n=10) were used in this study. Each type of abutments group was divided into two sub-groups: five were subjected to airborne particle abrasion with 50µm alumina before cementation. The other five did not receive any surface treatment (Control). All crowns were manufactured by CAD/CAM with a luting-gap of 36µm. All specimens were bonded to the titanium-based abutments using a dual-cure resin cement (Panavia V5, Kuraray). Bonding surfaces of Y-TZP zirconia ceramic copings were pretreated with 50µm alumina airborne particle abrasion and a silane coupling agent (Clearfil Ceramic Primer, Kuraray). Prior to mechanical testing, all copings were stored under moist condition at 37°C for 24h. All specimens were subject to a pull-out tensile test using a universal testing machine (Instron 5566A) with a crosshead speed of 1mm/min until complete separation. Maximum force was recorded as the retention force between crown and abutment. Data was analyzed with one way ANOVA.

Results: Pull-out retention forces for control groups of 3.5mm, 5.5mm height were 339.87±117.88N and 275.82±54.24N respectively. For airborne particle abraded groups, the retention forces for 3.5mm and 5.5mm were 537.61±80.13N and 707.03±32.30N respectively.Failure modes were predominantly adhesive. Air-abraded groups showed significantly greater retention than control groups ($P < 0.001$). No significant difference was found between the two heights of titanium abutments.

			Load at failure, N		
Implant Type	Treatment	N	Mean	Std Dev	CV
3.5 mm	Control	5	339.87	117.88	34.68
	Treated	5	537.61	80.13	14.90
5.5 mm	Control	5	275.82	54.24	19.67
	Treated	5	707.03	32.30	4.57

Table 1: Pull-out retention forces

Conclusion: Abutments subjected to particle abrasion produced significantly increased retention forces to Y-TZP zirconia crowns bonded to titanium abutments. The height of titanium-based abutments does not have a significant effect on vertical retention force.

Funding/Conflict of Interest: None

Keywords: dental abutments, particle abrasion, cementing strength, prosthesis retention, yttria-stabilized tetragonal zirconia polycrystals

L07: Laboratory Research, Student Scientist

Influence of a Novel Self-Priming Etchant on Bond-Strength to Glass-Ceramics

Haifa Alsobiyl[a]*, Abdulrahman Alshabib[a], Neimar Sartori[a], Sillas Duarte[a], Jin-Ho Phark[a]

[a]Herman Ostrow School of Dentistry of University of Southern California, Los Angeles, CA, USA

Purpose: To evaluate the influence of a novel self-priming ceramic etchant on micro-tensile bond strength (µTBS) to leucite reinforced glass-ceramic and lithium-disilicate reinforced glass-ceramic.

Materials and Methods: CAD/CAM Blocks were cut into 6mm sections, and polished up to -600 grit with silicone carbide paper. Resin nanoceramic (Lava Ultimate) blocks were sandblasted for 20s, cleaned with Ethanol in an ultrasonic bath for 10 min, dried, and porcelain silane was applied for 30s.Lithium disilicate reinforced glass-ceramic (IPS e.max CAD), and Leucite reinforced glass-ceramic (IPS Empress CAD) blocks were cleaned by the immersion in ethanol ultrasonic bath for 10 min before bonding procedures.Leucite reinforced glass-ceramic (Empress CAD) specimens were assigned to the following groups according to the surface treatment protocol: G1: No surface treatment, G2: 60s HF acid, no silane, G3: 60s HF acid, silane, G4: MBEP 20s and left for 40s, G5: MBEP 20s and left for 100s.For Lithium disilicate reinforced glass-ceramic (IPS e.max CAD) surface treatment protocols were: G6: 20s HF, silane, G7: MBEP 20s and left for 40s, G8: 20s HF, no silane, G9: No surface treatment, G10: MBEP 20s and left for 100s.All ceramic specimens were cemented with a dual cure resin cement (RelyX Ultimate) to resin nanoceramic (Lava Ultimate), then sectioned and subjected to mTBS testing using a Universal Testing Machine (Instron) after 24 h or 6 months of storage in distilled water. For all materials, surface treatments, and agents contact angle measurements were performed using a goniometer. Mann-Whitney and Kruskal-Wallis tests were perforemd for statistical analysis with $\alpha=0.001$.

Results: For groups 1-5, µTBS ranged from 21.45 to 45.15 MPa for non-aged specimens and from 0 to 38.81 MPa for aged specimens. For groups 6-10 µTBS ranged from 0 to 49.50 MPa for non-aged specimens and from 0 to 32.10 MPa for aged specimens (Table 1). Contact angle varied between different surface treatments and agents.

Group	Ceramic	Etching	Silanization	µTBS in MPa ± SD	
				24 H	6 M

1	(*IPS Empress CAD*)	none	none	21.45 ± 12.98	0
2		HF acid for 60 s	none	33.31 ± 11.75	19.41±20.84
3		HF acid for 60 s	Silane 60 s	44.88 ± 14.40	36.92±12.76
4		MBEP applied for 20 s and left for 40 s		41.92 ± 10.74	36.52±12.80
5		MBEP applied for 20 s and left for 100 s		45.15 ± 11.16	38.81±10.67
6	(*IPS e.max CAD*)	none	none	0	0
7		HF acid for 20 s	none	32.35± 28.09	5.18± 6.60
8		HF acid for 20 s	Silane 60 s	49.50 ± 11.15	35.93 ± 18.25
9		MBEP applied for 20 s and left for 40 s		41.33± 15.61	0.95± 4.95
10		MBEP applied for 20 s and left for 100 s		12.03±15.59	6.52±11.38

Table 1: Experimental groups, surface treatment and µTBS results

Conclusion: Long term efficacy of self-priming ceramic primer is highly dependent on the ceramics' composition and structural arrangement.

Funding/Conflict of Interest: The Advanced Operative and Adhesive Dentistry Department at Herman Ostrow School of Dentistry of USC. Authors declare no conflict of interest

Keywords: glass ceramics, self-etching ceramic primer, silane, HF acid

Abstracts to the Second Biennial Meeting of the International Academy of Adhesive Dentistry, June 16-17, 2017

L08: Laboratory Research

Comparison of In-Vitro Shear Bond Strengths of Resin Based Self-Adhesive Luting Cements on Ceramics & Ceramic Hybrid Materials

Kishwar Hoque[a]*, Jason Guzman[a], Allan S. Deutch[a], Barry L. Musikant[a]

[a]Essential Dental Systems, NJ, USA

Purpose: To compare the in vitro shear bond strength of EDS "Envy" luting cement with other commercially available self-adhesive luting cements, namely, RelyX Unicem 2, Maxcem Elite, and SpeedCem.

Materials and Methods: The study was conducted by light curing self-adhesive luting cements using a translucent conical mold (dimensions: r1 = 5 mm, r2 = 7 mm, h = 9 mm) to ingots of four different types of substrates: zirconia (Bruxzir), lithium disilicate (IPS e.max Press), resin nano-ceramics (Lava Ultimate), and a hybrid ceramic composite (Vita Enamic). The test specimens were mounted in cylindrical molds of acrylic and then incubated for 24 hours at 37 °C in 100% humidity. Shear bond strength was measured using an MTS load frame, Model 42, equipped with a 1000 N load cell. The peak load required (N) to break the bond between the cement and the substrate was recorded. Bond strength (MPa) was calculated using the following formula: Bond Strength (MPa) = Force (N)/Surface Area (mm^2)

Results: The average strengths of the adhesives on various composites (MPa) are shown in Figure 1.

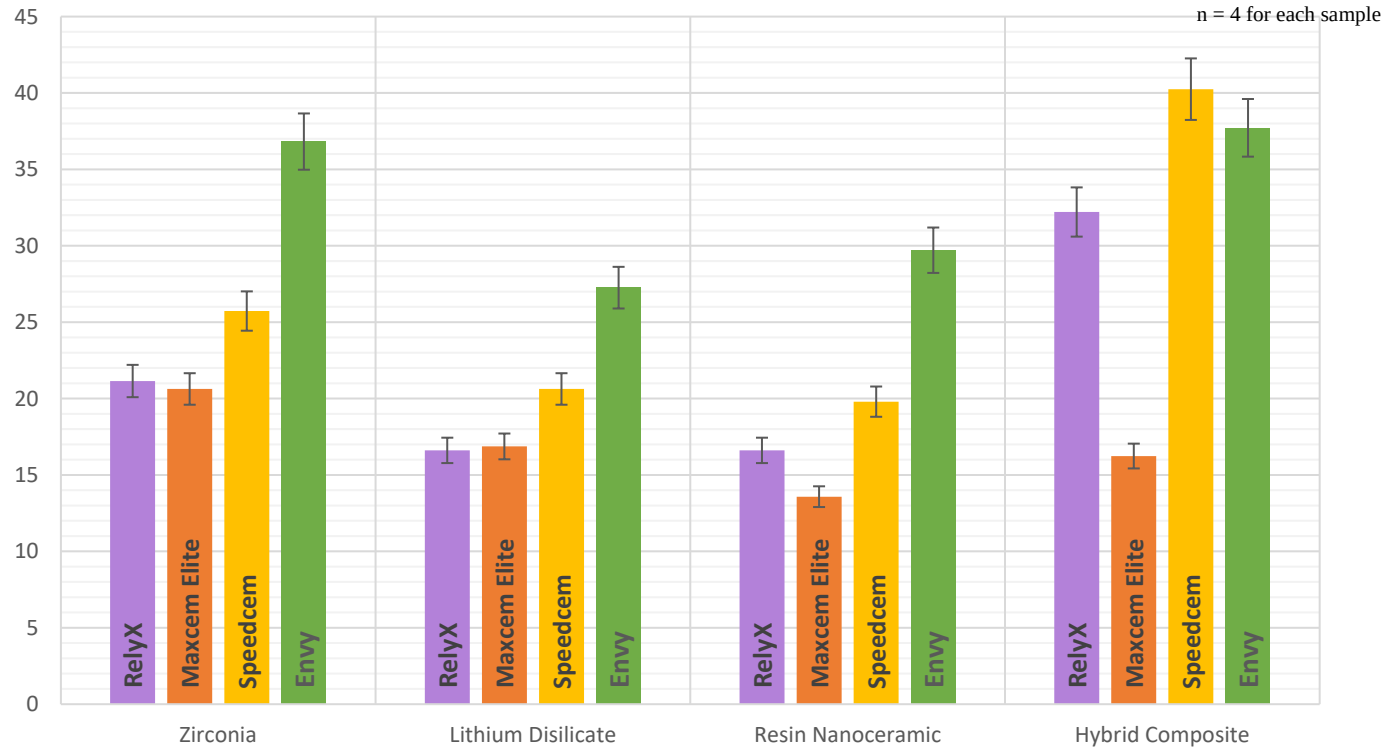

Figure 1: Shear bond strength values

Conclusion: With the exception of the Hybrid Composite material (Vita Enamic), the study shows that EDS "Envy" self-adhesive luting cement has superior bond strength when adhered to the various ceramic surfaces.

Funding/Conflict of Interest: All authors are employees of Essential Dental Systems.

Keywords: bond strength, self-adhesive, resin

L09: Laboratory Research

Influence of Different Laser Irradiation Energy on Ceramic Bond Strength

Cesar R. Pucci[a]*, Danilo de S. Andrade[a], Fernanda A. Feitosa[a], Rodrigo M. de Araújo[a], Pablo L. Benitezv[a], Franklin R. Tay[b]

[a]Institute of Science and Technology, São Paulo State University UNESP, São Jose dos Campos, São Paulo, Brazil
[b]Dental College of Georgia at Augusta University, Augusta, GA, USA

Purpose: This study aimed to verify the influence of differents Nd:YAG laser energy parameters on the bond strength between lithium disilicate ceramic and resin cement.

Materials and Methods: Lithium disilicate ceramic specimens (n=100) with truncated cones shape were prepared and divided into 5 groups: 1- Control (without laser irradiation); 2- 80Nd – laser irradiation with Nd:YAG laser at 80 mJ energy intensity for 1 min; 3- 100Nd - irradiation with Nd:YAG laser with an intensity of 100 mJ for 1 min; 4- 120Nd - Nd:YAG laser irradiation with an intensity of 120 mJ for 1 min; 5- 140Nd - Nd: YAG laser irradiation with an intensity of 140 mJ for 1 min. Laser irradiation of the specimens was performed on the lower base of the truncated cones. After lasers treatments, the groups were etched with 10% hydrofluoric acid for 1 min and silanized. Half of the treated ceramic specimens were cemented with resin cement (Variolink II, Ivoclar-Vivadent) to the other half, resulting in hourglass-shaped specimens (n=10). The bonded specimens were cycled thermomechanically and stressed to failure under tension. Data were analyzed using ANOVA and Tukey tests ($\alpha = 0.05$).

Results: A statistically significant differences was observed among groups ($p = 0.0$). The 80Nd group (21.22 ± 6.00) had significantly higher bond strength than the other groups, which were not significantly different from one another (Control- 12.37 ± 3.46; 100Nd- 15.15 ± 5.89; 120Nd- 14.61 ± 2.53; 140Nd- 10.12 ± 4.23; results in MPa).

Conclusion: Laser energy intensity parameter significantly affects the tensile strength of resin cement to lithium disilicate ceramic.

Funding/Conflict of Interest: Fapesp-Proc.2014/04693-3

Keywords: ceramics, laser, dental materials, dental cements

L10: Laboratory Research, Junior Scientist

Influence of Ambient Temperature and Light-Curing Moment on Polymerization Shrinkage and Strength of Resin Composite Cements

Nadja Rohr[a]*, Johanes Müller[a], Jens Fischer[a]

[a]University Center for Dental Medicine, University of Basel, Basel, Switzerland

Purpose: Purpose of this study was to establish a clinically appropriate time point of light curing for resin composite cements while achieving best material properties and lowest polymerization shrinkage.

Materials and Methods: Polymerization shrinkage of 7 resin composite cements (Multilink Automix, Multilink Speed Cem, RelyX Ultimate, RelyX Unicem 2 Automix, Panavia V5, Panavia SA plus, VITA Adiva F-Cem) was measured at ambient temperatures of 23 and 37°C. Polymerization shrinkage was assessed of autopolymerized and light-cured specimens after light application at 1, 5 or 10min after mixing. Indirect tensile strength of all cements was measured after 24h storage at temperatures of 23 and 37°C, for autopolymerized and light cured specimens after light application 1, 5 or 10 minutes after mixing. To illustrate filler size and micro-structures, SEM images of all cements were captured. Statistical analysis was performed with one-way ANOVA followed by post-hoc Fisher LSD test ($p<0.05$).

Results: Clinically relevant polymerization shrinkage at 37°C with light application 5 min after mixing ranged from 4.0 to 5.8%. Polymerization shrinkage of the cements did not correlate with the indirect tensile strength of the cement in the respective group. Highest indirect tensile strengths were observed for the materials containing a homogeneous distribution of fillers with a size of about 1 µm (VITA Adiva F-Cem, Multilink Automix, Panavia V5).

Conclusion: The effect of light-curing and temperature on the polymerization shrinkage as well as indirect tensile strength of dual-curing resin composite cements is material related.

Funding/Conflict of Interest: Funding/conflict of interest: The study was supported with materials by VITA Zahnfabrik, Bad Säckingen, Germany. There are no conflicts of interest.

Keywords: polymerization shrinkage, indirect tensile strength, SEM, resin composite cement, light-curing, autopolymerization, temperature

L11: Laboratory Research, Junior Scientist

Effect of Composite Polymerization Stress on Dentin Micro-Permeability of Restorations

Bruna Marin Fronza[a]*, Gabriel Flores Abuna[a], Roberto Ruggiero Braga[b], Frederick Allen Rueggeberg[c], Marcelo Giannini[a]

[a]Piracicaba Dental School - UNICAMP, Piracicaba, São Paulo, Brazil
[b]School of Dentistry, University of São Paulo, São Paulo, Brazil
[c]Dental College of Georgia at Augusta University, Augusta, GA, USA

Purpose: To investigate the effect of polymerization stress and insertion technique of composites placed under pulpal pressure on dentin micro-permeability in class I restorations.

Materials and Methods: One high-viscosity conventional (HCR), one low-viscosity conventional (LCR), one high-viscosity bulk fill (HBF) and one low-viscosity bulk fill (LBF) composite were evaluated. Polymerization stress was measured with materials bonded to acrylic rods in a universal testing machine (n=5). Class I cavities were made in extracted molars, which teeth roots were removed and the pulpal chambers cleaned. Cavities were coupled to a hydraulic device to simulate pulpal pressure during composite placement (n=5). Conventional composites were placed in two horizontal increments, while bulk fill materials in one-single increment. Fluid flow rate (mL/min) and dentin micro-permeability (%) were monitored. Restoration interface was observed under confocal laser scanning microscopy.

Results: FCR and LBF presented statistically significant higher polymerization stress than CCR and HBF. Fluid flow rate and dentin micro-permeability did not differ among the groups (Table 2). However, different patterns of fluid infiltration and interface integrity were observed. CCR and HBF presented well-sealed surrounding margins with small gaps in pulpal wall, while HBF demonstrated more cracks in the adhesive layer. FCR and LBF restorations had larger gaps along all the interface (Figure 1).

Table 2. Means (standard deviation) of polymerization stress, fluid flow rate and permeability of the resin-bonded restoration.

Material	Shrinkage stress (MPa)	Fluid flow rate (µl/min)	Micro-permeability (%)
Conventional composite (HCR)	2.83 (0.20) b	0.14 (0.07) a	17.51 (6.48) a
Conventional flowable composite (LCR)	4.25 (0.40) a	0.22 (0.06) a	24.64 (6.17) a
High-viscosity bulk fill composite (HBF)	2.76 (0.27) b	0.21 (0.09) a	22.22 (8.87) a
Low-viscosity bulk fill composite (LBF)	3.87 (0.29) a	0.12 (0.08) a	15.68 (5.20) a

Within each column, means followed by the same letter are not statistically different (p>0.05).

Table 2: Mean polymerization stress values

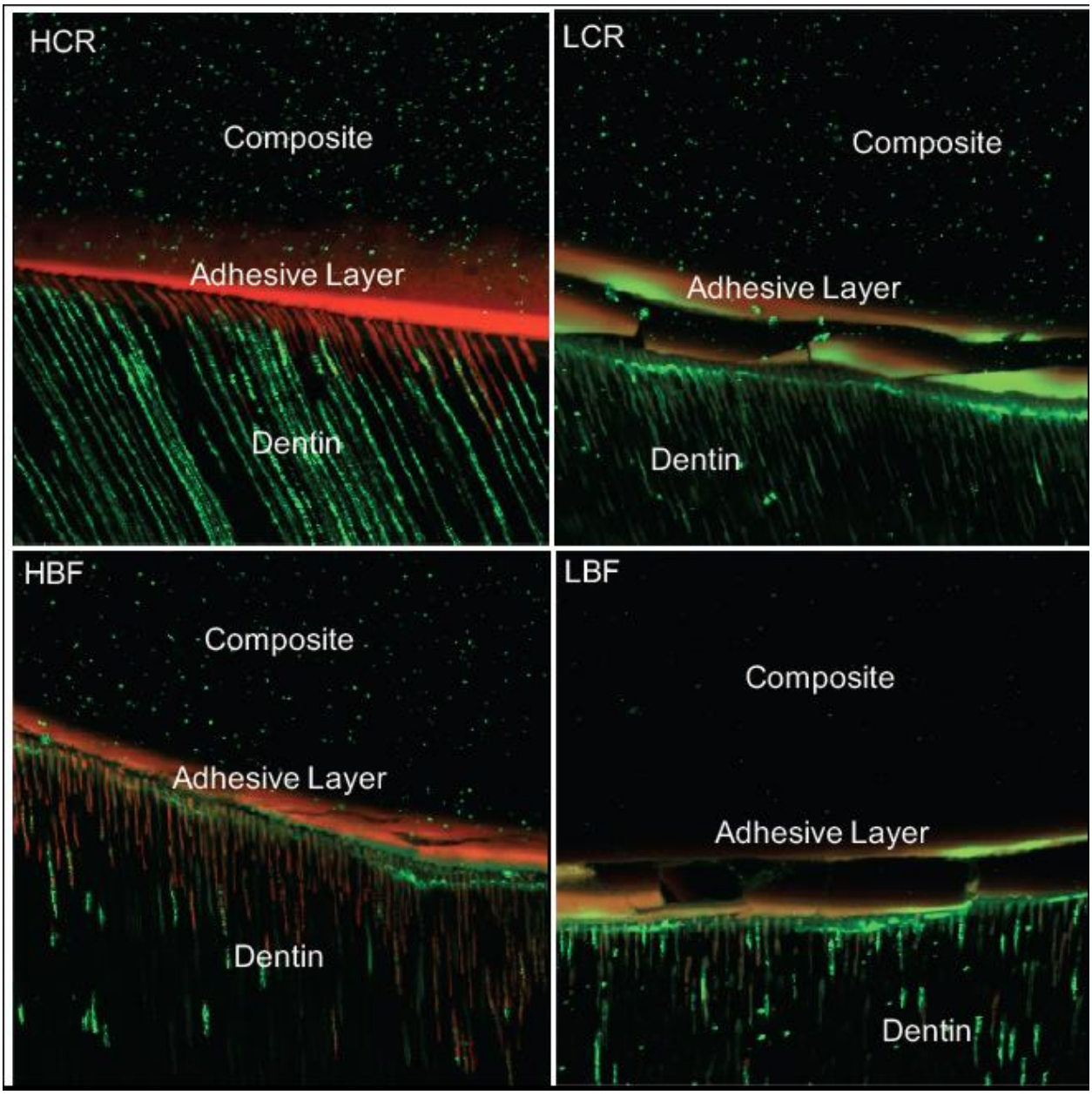

Figure 1: Confocal scanning microscopy images

Conclusion: No difference in polymerization stress was found when conventional and bulk fill composites with similar viscosities were compared. Dentin micro-permeability was not influenced by the material polymerization stress and restoration placement techniques. However, a better interfacial integrity was observed with the conventional high-viscosity composite placed incrementally.

Funding/Conflict of Interest: Funding: This study was supported by Coordination for the Improvement of Higher Education Personnel (CAPES #1777-2014) and National Council for Scientific and Technological Development (CNPq #307217-2014-0).

Keywords: composite resins, stress analyses, dental bonding, dentin permeability.

L12: Laboratory Research, Junior Scientist

Pulpal Responses to Direct Pulp Capping Material Containing Phosphorylated Pullulan.

Yu Toida[a]*, Shimpei Kawano[a], Shihchun Ting[a], Rime Shamme Akter[a], Pimpinee Eamsa-ard[a], Zubaer Ahmed[a], AFM Almas Chowdhury[a], Pipop Saikaew[a], Eri Seioku[a], Mariko Matsumoto[a], Shinichi Kakuda[a], Shuhei Hoshika[a], Takatsumi Ikeda[a], Shigeaki Abe[a], Yasushi Shimada[b], Denis Selimovic[a], Yasuhiro Yoshida[a], Hidehiko Sano[a]

[a]Graduate School of Dental Medicine, Hokkaido University, Sapporo, Japan,
[b]Graduate School of Medicine, Okayama University, Okayama, Japan

Purpose: The purpose of this study was to evaluate monkey pulpal responses to a newly developed mineral trioxide aggregate (MTA) based direct pulp capping material which contains phosphorylated pullulan that adheres to hard tissue and implies high biological compatibility. Sealing ability of this material using scanning electron microscopy (SEM) was also evaluated.

Materials and Methods: One hundred and twenty cavities were prepared in five monkey's teeth. The pulps were intentionally exposed and randomly divided into four groups according to pulp capping materials : a newly developed MTA direct pulp capping material which contains phosphorylated pullulan (PL, GC), NEX-MTA cement (NX, GC), Theracal LC (TH, Bisco) and Dycal (DY, Dentsply). After that, one-step self-etch adhesive (G bond plus; GC) was applied and filled with flowable composite (MI flow 2, GC). The teeth were then extracted after 3, 7 and 70 days, fixed in 10% buffered formalin solution, and prepared according to routine histological techniques. Tissues were demineralized and subsequently sectioned. Four micrometer sections were stained with hematoxylin-eosin, or alkaline phosphatase for micromorphological observation. SEM observation was performed to study the pulp capping material-dentin interface.

Results: No necrosis or abscess formation was observed in any of the experimental groups. Disarrangement of odontoblasts layer at 3 and 7 days and deposition of thick reparative dentin were the major reaction observed for these materials at 70 days except for DY. For DY, reparative dentin was very thin and dentinal tubes could not be observed at 70 days. PL showed good sealing ability imaged by SEM

Conclusion: Pulp capping with three different MTA types (PL, NX and TH) provided acceptable pulpal responses and biological compatibility to the monkey pulp. PL showed a good sealing ability.

Funding/Conflict of Interest: None

Keywords: pulp capping material, dental pulp calcification, histology, SEM, dental seal

L13: Laboratory Research, Junior Scientist

Bioactive Rechargeable Dental Adhesive Based on Calcium Phosphate Nanoparticles to Inhibit Demineralization

Mary Anne Sampaio De Melo[a]*, Xianju Xie[b], Dan Xing[c], Michael D. Weir[a], Mark Reynolds[a], Yuxing Bai[b], Hockin Xu[a]

[a]School of Dentistry, University of Maryland, Baltimore, MD, USA
[b]School of Stomatology, Capital Medical University, Beijing, China
[c]China Rehabilitation Research Center, Beijing, China

Purpose: Bioactive dental adhesives are attractive biomaterials for various applications in Dentistry. A potential application would be orthodontic adhesive to inhibit white-spot lesions (WSL) in enamel, which are a major complication for orthodontic treatments. The objective of this study was to develop a novel rechargeable dental adhesive containing nanoparticles of amorphous calcium phosphate (NACP) to have calcium (Ca) and phosphate (P) ion release, recharge and durable re-release capabilities to enhance tooth structure remineralization and inhibit demineralization.

Materials and Methods: NACP were synthesized using a spray-drying technique. The resin matrix consisted of ethoxylated bisphenol A dimethacrylate (EBPADMA) and pyromellitic glycerol dimethacrylate (PMGDM). The resin was filled with five groups of fillers to yield five adhesives: (1) 60% glass particles (control without NACP); (2) 40% glass + 20% NACP; (3) 30% glass + 30% NACP; (4) 20% glass + 40% NACP; (5) 10% glass + 50% NACP. Orthodontic bracket shear bond strength (SBS) to enamel, Ca and P ion initial release, recharge and re-release were tested.

Results: The new NACP adhesives had SBS similar to commercial orthodontic adhesive without CaP release ($p > 0.1$). The adhesives had Ca and P ion release, which increased with increasing the NACP content ($p < 0.05$). After the ion release was exhausted, the recharged adhesives once again had substantial releases of Ca and P ions continuously for 14 days without additional recharge. The ion re-release ability did not drop over time with repeated recharge and re-release times ($p > 0.1$). The ion re-release concentrations were linearly proportional to the NACP filler level. Novel NACP adhesive had substantial Ca and P ion release, recharge and long-term re-release, while possessing good bond strength to enamel, suitable for orthodontic use to inhibit enamel demineralization and WSL.

Conclusion: The novel rechargeable adhesives are promising for orthodontics, crown cements, cavity liners, varnishes and composites, and other preventive and restorative applications.

Funding/Conflict of Interest: NIH R01 DE17974 , NSF of China 81200820, 81400487, Beijing Nova Program, Beijing Municipal Administration of Hospitals' Ascent Plan DFL 20151401 and University of Maryland School of Dentistry bridging fund.

Keywords: dental adhesive, enamel demineralization, calcium phosphate nanoparticles, rechargeable, long-term ions release, bond strength

L14: Laboratory Research, Junior Scientist

Three-Dimensional In-Vitro Comparative Study of 3D-Printed and Milled CAD Geometrical Model

Evanthia Anadioti[a]*, Brittany Kane[a]

[a]School of Dental Medicine, University of Pennsylvania, Philadelphia, PA, USA

Purpose: At the beginning of the digital era in the dental field, the utilization of 3D printing technology expands and has the potential to drive significant growth. Rapid prototyping technologies differ from CAD/CAM machines that rely exclusively in subtractive methods such as milling. There are clear advantages to 3D printing that demand research attention. The purpose of this in-vitro study was to compare the dimensional accuracy of CAD geometrical model fabricated by three 3D printers and a milling machine.

Materials and Methods: A simplified CAD model was designed with 3D software(GOM Inspect). The test samples were fabricated with three 3D printers(ProJet6000, Fortus450mc, and FormLab2) and one milling machine(Zirkonzahn M1) with their respective materials approved for dental use. The printed and milled specimens were then scanned with a laboratory scanner(S600 from Zirkonzahn) with high accuracy. Each respective STL file was superimposed on the original CAD file for three-dimensional linear analysis and comparisons using the same software.

Results: One Way ANOVA on Ranks followed by Tukey test was run to compare the printing and milling machines for accuracy in three different dimensions (x, y and z). M1 Milling Basic was not statistically significantly different from the control (CAD model) in any of the three dimensions ($p<0.05$). Fortus450mc was not statistically significantly different from the control in x-dimension while FormLab2 was not different in z-dimension. All other groups were significantly different from the control and each other in all dimensions.

Conclusion: We conclude that the milling machine is more dimensionally accurate than the 3D printers used in this study for the fabrication of the CAD model. The data demonstrates that there are dimensional differences when comparing the 3D printers amongst themselves. While the accuracy of the 3D printers was less than that of the milling machine within the confines of this study, this new technology may produce models that are clinically acceptable as compared to the gold standard of material for dental models, type IV stone. This was not accessed and future research on this subject matter could aid in the evolution of 3D printing's potential in the dental field.

Funding/Conflict of Interest: None

Keywords: 3D printing, rapid prototyping, CAD/CAM, geometrical model, dimensional accuracy

L15: Laboratory Research

Incremental and Bulk-Filling Techniques in High and Low C-Factor Cavities

Seung-Hoon Han[a]*, Sung-Ho Park[b]

[a]St.Vincent Hospital, Catholic University of Korea, Suwon, Korea
[b]College of Dentistry, Yonsei University, Seoul, Korea

Purpose: To compare the micro-tensile bond strength of incremental and bulk fill techniques under different C-factor and compliance conditions.

Materials and Methods: Extracted human third molar teeth were divided into 3 experimental groups. For group I, Class I cavities were prepared. For group II, MOD cavities of the same size were prepared. For group III, cavities were prepared as in group II, except with high compliance cavity walls. The specimens were measured for cavity wall compliance. Each of these groups was divided into four subgroups. Teeth were restored using two different materials-TB (Tetric N-ceram Bulk-Fill; Ivoclar vivadent) and VB (Venus Bulk-Fill; Heraeus Kulzer)-and by either incremental or bulk fill technique. Then, micro-tensile bond strength (μ-TBS) was measured and compared. The polymerization stresses of the composites were calculated using a custom-made device. The results were analyzed by Kruskal-Wallis test and Weibull analysis.

Results: In group I, the μ-TBS obtained using the incremental technique was significantly higher than that obtained by the bulk fill technique ($p < 0.05$). In contrast, no difference in μ-TBS was observed between the two techniques in groups II and III. The μ-TBS measured in group I was significantly lower than the μ-TBS measured in groups II and III ($p < 0.05$). No statistical difference in μ-TBS was observed when cavities were filled with either TB or VB ($p > 0.05$).

Conclusion: The incremental technique showed higher bond strength than the bulk fill technique in the high C-factor cavity. However, no difference was found between the two techniques in the low C-factor cavity. The bond strength in the high C-factor cavity was significantly lower than the bond strength in the low C-factor cavity.

Funding/Conflict of Interest: None.

Keywords: incremental technique, bulk fill technique, micro-tensile bond strength, C-factor, compliance, resin composite

L16: Laboratory Research

Performance of a Metal Salt Based Enamel / Dentin Etchant

Thorsten Bock[a]*, Delphine Catel[a], Siegward Heintze[a], Marie Reinhardt[a]

[a]Ivoclar Vivadent, Schaan, Liechtenstein

Purpose: To remove debris from cavity preparation and create micro-retentive enamel-etch-patterns, dental hard-tissue is often etched with phosphoric-acid-gel ("PAG"). While effective on enamel, PAG-treatment of dentin can cause over-etching, is sensitive to degree of surficial dentin moisture and may reduce long-term dentin-bond-strength. We investigated an alternative etchant based on 10% ZrO(NO3)2 (zirconyl-nitrate) in aqueous-organic-solvents ("ZON") to overcome these shortcomings. We compared PAG and ZON regarding shear-bond-strength and enamel-margin-integrity in Class-II-restorations.

Materials and Methods: Tooth-surfaces were etched 30s (enamel) or 15s (dentin) using PAG (Total Etch; Ivoclar-Vivadent) or ZON. The adhesives ExciTE F and Adhese-Universal ("EXF", "AU"; Ivoclar-Vivadent) and the composite Tetric EvoCeram BulkFill ("BUFI"; Ivoclar-Vivadent) were employed according to instructions-for-use. Shear-bond-strength (ISO-29022) was tested on bovine teeth. Dentin was either blot-dried (tissue-paper, "wet") or air-dried (4bar/5s, "dry"). Enamel was always tested in dry state. SBS samples (N=5) were aged (24h/37°C/water). Enamel-margin-integrity was assessed in Class-II two-surface-restorations (4 human lower molars, 2 non-retentive cavities/tooth; depth/width of proximal box: 4mm/5mm). In each tooth, one cavity was PAG-conditioned / ZON-conditioned before restoration with EXF/BUFI. After thermo-cycling (10'000cycles/5-55°C), percentage of regular enamel-proximal-margin was evaluated (SEM, 200x-magnification.

Results: Both adhesives gave comparable SBS to dry enamel or wet dentin for ZON and PAG. Significantly higher SBS on dry dentin was obtained with ZON (Table 1). The percentage of regular enamel margin obtained with both etchants was not statistically significantly different (Table 2).

Shear-bond-strength [MPa]						
Substrate	**Enamel (30s)**		**Dentin (15s)**			
Etchant	**PAG**	**ZON**	**PAG**		**ZON**	
Surface	**Dry**		**Wet**	**Dry**	**Wet**	**Dry**
EXF	32.0±1.5[a]	25.9±2.3[a]	27.8±5.4[c]	11.2±2.9[d]	33.0±4.1[f]	27.3±3.6[f]
AU	29.0±1.7[b]	27.9±2.9[b]	37.7±9.3[e]	37.0±3.4[e]	40.0±4.0[g]	40.6±6.5[g]
Same letters denominate same statistical group (ANOVA, p>0.05).						

Table 1: Shear-bong strength values

Enamel-Margin-Integrity [% regular margin]	
PAG	89±9%[a]
ZON	80±12[a]
Same letters denominate same statistical group (ANOVA, p>0.05).	

Table 2: Enamel margin integrity

Conclusion: Adhesion to ZON-conditioned dentin proved more tolerant to varying surface-moisture than PAG-conditioning. Enamel-margin-integrity of thermo-cycled Class-II-restorations was comparable for ZON- and PAG-conditioning. Within limitations of this study, ZON is considered helpful overcoming issues associated with PAG-etching of dentin.

Funding/Conflict of Interest: All authors are employees of Ivoclar Vivadent.

Keywords: dentin Bonding, chemistry, dental materials

L17: Laboratory Research

Voids Formation and Adhesion Performance of Bonding Agent

Kosuke Honda[a]*, Akishi Arita[a], Tomohiro Kumagai[a]

[a]GC Corporation, Tokyo, Japan

Purpose: This study evaluated voids formation and bond strength of one-step self-etch adhesives to tooth structure.

Materials and Methods: Bovine dentin surfaces were ground with 320-grit SiC paper and divided into 4 groups (n=5 each): G-Premio BOND (GC) dried with strong air pressure (0.35 MPa, GPs); GP dried with weak air pressure (0.05 MPa, GPw); Scotchbond Universal Adhesive (3M ESPE) dried with weak air pressure (SUw); CLEARFIL Universal bond Quick (Kuraray) dried with weak air pressure (UQw). Adhesives were applied to the surface according to manufacturers' instructions and dried for 5 seconds with above mentioned air pressure. Adhesives were light cured via the ultradent mold (φ=2.38mm), and composite resin was applied via the mold and light cured. The bonded specimens were subjected to shear bond strength (SBS) test at 1 mm/min after stored in water at 37°C for 24 h. Data were analyzed using ANOVA followed by Tukey's test ($p<0.05$). Fracture surfaces were observed using scanning electron microscope (SEM).

Results: Mean (±SD) SBS values were 32.2 (±6.7), 25.5 (±3.7), 22.9 (±9.0), and 22.5 (±5.3) MPa for GPs, GPw, SUw, and UQw respectively. Mean SBS of GPs was significantly higher than UQw. Small voids less than 1 μm were observed in GPs, SUw, and UQw and relatively large voids more than 5 μm were observed in GPw.

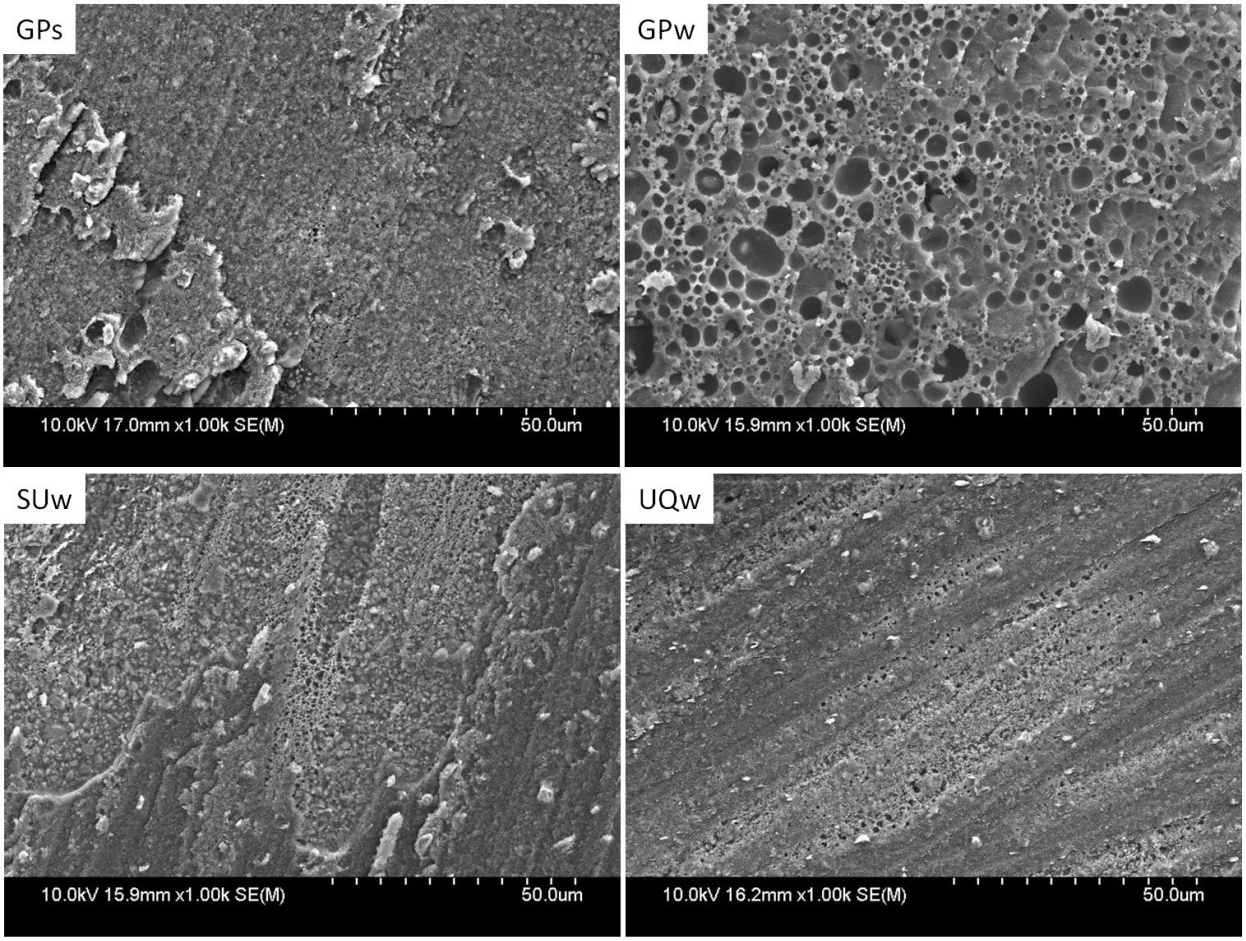

Figure 1: SEM pictures

Conclusion: Sides of voids had no impact on immediate bond strength of one step self-etch adhesives.

Funding/Conflict of Interest: All authors are employees of GC Corporation.

Keywords: Light-curing, dental adhesives, dentin-bonding agents

L18: Laboratory Research, Student Scientist

Bond Strength and Nanomechanical Properties of CHX Treated Dentin

Saro Atam[a]*, R. Wilson[a], Fusun Ozer[a], Hiroyuki Miyajima[a], Zeynep Batu[b]

[a]School of Dental Medicine, University of Pennsylvania, Philadelphia, PA, USA
[b]Faculty of Dentistry, Istanbul Aydin University, Istanbul, Turkey

Purpose: This study investigated the effect of CHX application on the dentin bond strength of a self-etch adhesive and nanomechanical properties of dentin surfaces.

Materials and Methods: Flat occlusal dentin surfaces were prepared after removing occlusal cusps of extracted human molars and polished with 600-grit SiC paper. Teeth were then divided into 2 groups ; chlorhexidine treatment (CHX) and, no treatment (control). Composite blocks were built up over the self-etch bonding agent (Clearfil SE Bond, Kuraray, Japan). The restored teeth were stored in distilled water at 37°C for 24h and then vertically sectioned to obtain 1.0 mm2 cross-sectional composite-dentin beams. Microtensile bond strengths (µTBS) were measured at a crosshead speed of 0.5mm/min. The data were analyzed by one-way ANOVA and Tukey's test. For the evaluation of the nanomechanical properties, 24 dentin slabs were obtained from 6 molar teeth and divided into 2 groups according to the dentin treatments. Immediately after treatments, hardness and elastic modulus of the dentin surfaces were evaluated using a nanoindentation technique with a Berkovich diamond indenter. Data were analyzed by one-way ANOVA and Tukey's test. Surface morphology and resin/dentin interfaces of samples were observed by Environmental Scanning Electron Microscope (ESEM).

Results: CHX application did not change bond strengths to dentin. No significant differences were found among the hardness and elastic modulus of dentin surfaces for both study groups. The ESEM pictures showed that application of CHX did not fully dissolve the smear layer.

µTBSs of the groups	
Groups	**[Mpa]**
Control	25,9±6,0[a]
CHX	24,2±6,1[a]
*Differences in superscript letters indicate statistical significance ($p < 0.05$).	

Table 1: Micro-tensile bond strength values

Conclusion: Pretreatment of dentin surfaces with CHX did not affect bonding performance of self-etch resin bonding system.

Funding/Conflict of Interest: None

Keywords: CHX, adhesive, bond strength, smear layer

L19: Laboratory Research

Shear Bond Strength of Universal Adhesives- Function of Curing Mode

Shashikant Singhal[a]*, Patrick McCabe[a], Omar Nihlalwi[a], Jason Pischka[a], Tabetha Magnuszewski[a], George Tysowsky[a]

[a]Ivoclar Vivadent, Inc., Amherst, NY, US

Purpose: The objective of the study is to compare shear bond strength of universal adhesive systems as a function of curing mode for glass ceramic restorations.

Materials and Methods: Sixty human molars were sectioned, mounted and ground to a flat dentin surface using 320/400/600 grit SiC polishing paper. Specimens (n=10) were randomly distributed into six experimental groups: Group 1, 2 [(Adhese® Universal (AU)/Variolink® Esthetic DC (VD))/Ivoclar Vivadent, Inc. (IV)], Group 3, 4 [(ScotchbondTM Universal (SU)/RelyXTM Ultimate)/3MESPE] and Group 5, 6 [(OptibondTM XTR (OX)/NX3 NexusTM)/KerrTM]. The adhesives were applied to dentin surface using self-etching technique per manufacturer's recommendations. The adhesives were light cured/(LC) per manufacturer's instructions for Groups 1/3/5 as a separate step. The lithium disilicate [(IPS e.max®/(IV)) rods (dimensions: 2.5x3mm) were finished (600 grit SiC-Paper), etched (HF 5%) and silanated [Monobond® Plus/(IV)]. The prepared rods were cemented to dentin under constant load and light cured on each side for 20 seconds. AU is a light cured adhesive system therefore Group-2 was considered as negative control. Specimens were stored in an incubator for 24 hours (37°C/100% humidity). Shear bond strength was measured using an Instron® Universal Testing Machine with a crosshead speed of 1.0 mm/min. The fractured surfaces of each specimen were evaluated. Data was analyzed by one-way Analysis of Variance (ANOVA) and Tukey's HSD post-hoc test (α=0.05).

Results:

	Mean±SD(MPa)
Group-1	45.1 ± 3.9^{A}
Group-2	15.3 ± 3.0^{CD}
Group-3	51.2 ± 5.1^{A}
Group-4	13.2 ± 2.6^{B}
Group-5	51.2 ± 9.0^{A}
Group-6	18.8 ± 8.0^{D}

Groups showing different superscripts were significantly different (α=0.05).

Table 1: Shear bond strength values

Conclusion: Within the limitation of this study, light polymerization of dental adhesives as a separate step has shown significantly higher bond strength for all tested adhesives compared to light polymerization of adhesives and resin cements together.

Funding/Conflict of Interest: All authors are employees of Ivoclar Vivadent.

Keywords: immediatye dentin sealing, universal bonding agents, Adhese Universal

L20: Laboratory Research, Junior Scientist

Interfacial Integrity of Deep Class-II Bulk-Fill Composite Restorations

Rana A. Sedky[a]*, Yuping Li[b], Bonita VanHeel[b], Young Heo[b], Alex Fok[b]

[a]Ain-Shams University, Cairo, Egypt
[b]University of Minnesota, Minneapolis, MN, USA

Purpose: To evaluate the interfacial integrity of deep Class-II restorations prepared with bulk-fill resin composites of different handling characteristics and different incremental thicknesses.

Materials and Methods: Twenty human molars were divided into four groups (n=5) according to the material (Filtek™ Bulk Fill Flowable, BF, or Filtek™ Bulk Fill Posterior, BR) and thickness for the first increment (4mm or 2mm). Proximal cavities of 6mm (depth) x 4mm (bucco-lingual width) x 2mm (mesio-distal width) were prepared. Three-step etch-&-rinse adhesive (Optibond FL, Kerr) was applied, followed by placement of the first increment of composite. BR was used as a capping material for all specimens. All restorations were cured with an LED blue light operated at 1200 mW/cm2. Acoustic emission (AE) was detected using an AE sensor attached onto the surface of the specimens, monitoring debonding from the start of curing for 10 minutes. Micro-CT images of the restorations were captured before and after curing to further assess interfacial integrity. Twenty-four hours after curing, the specimens were sectioned mesio-distally and polished using SiC paper. Vicker's microhardness (VHN) was measured with a 100g load and 20s dwell time at depth intervals of 0.5mm occluso-gingivally. Data was analyzed using Two-Way ANOVA.

Results: For AE, Two-Way ANOVA revealed statistically significant difference between the materials (BF: 9.1±4.0 vs. BR: 4.8±3.4, $p=0.011$) but no significant difference between the first increment thicknesses (4mm: 6.7±4.6 vs. 2mm: 7.2±3.4, $p=0.741$). The same was found for VHN with values between-materials: BR 68.7 ±8.4 vs. BF 37.9±5.1, $p=0.0001$; and between-first increment thicknesses: 4mm: 52.7±16.3 vs. 2mm: 51.4 ±17.3, $p>0.05$. Micro-CT images showed interfacial gaps in samples restored with 4mm-thick first increment using BF.

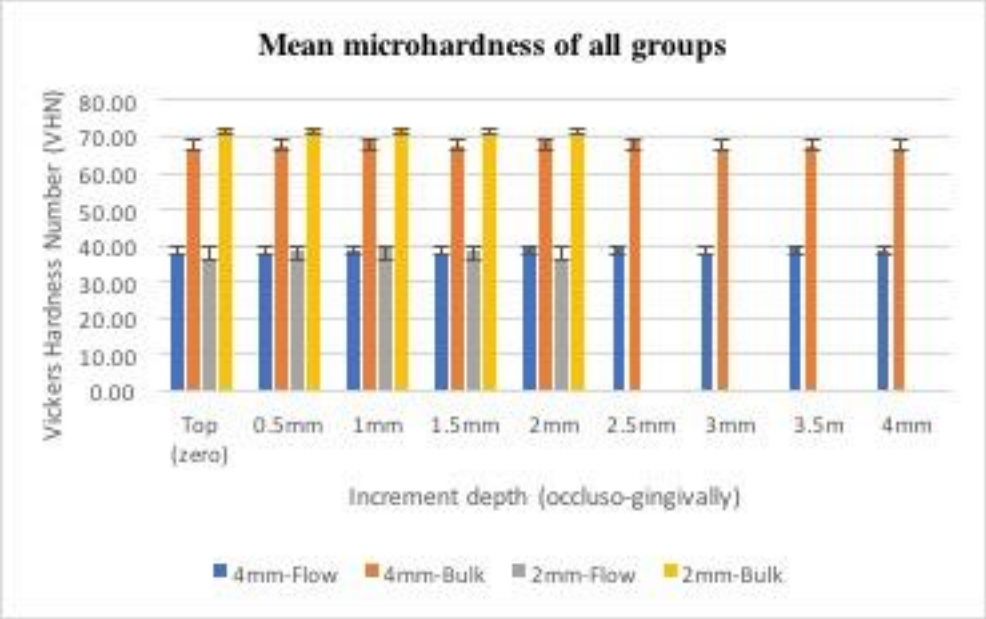

Figure 1: Mean micro hardness values

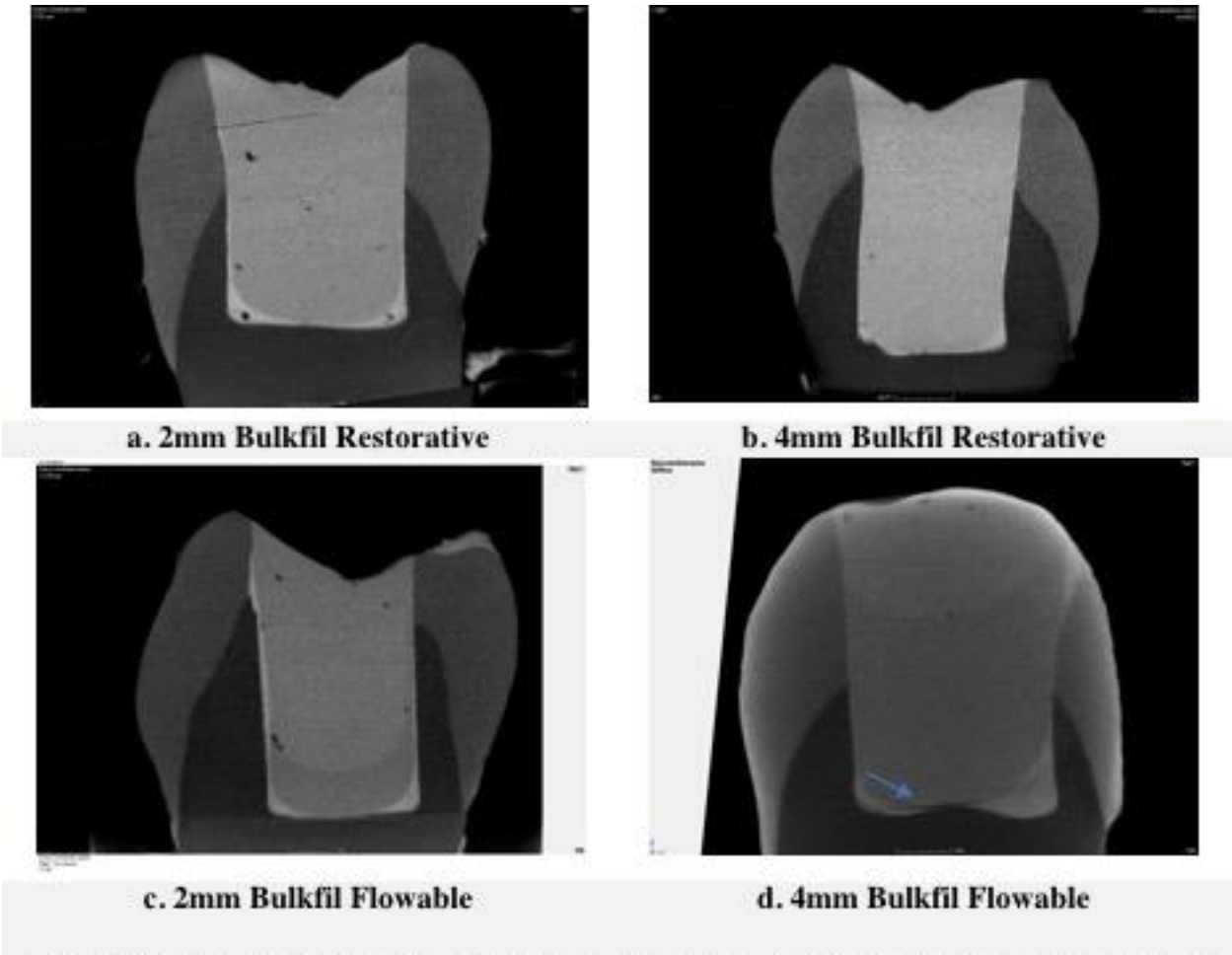

Figure (2): Representative micro-CT images for all groups. (arrow indicates debonding)

Figure 2: Micro-CT images

Conclusion: Use of flowable bulk-fill composites in 4mm increments seems to produce more interfacial debonding, despite adequate cure throughout the depth.

Funding/Conflict of Interest: 3M provided the materials used in this study. Authors declare no conflict of interest

Keywords: dental debonding, composite resin, hardness test, x-ray micro CT

L21: Laboratory Research

Effect of Preheating on the Flow Properties of Resin Composites

Fusun Ozer[a]*, Zeynep Batu[b], Christopher Lai[a], Madison Richards[a], Markus B. Blatz[a]

[a]School of Dental Medicine, University of Pennsylvania, Philadelphia, PA, USA
[b]Faculty of Dentistry, Istanbul Aydin University, İstanbul, Turkey

Purpose: The aim of this study was to evaluate the effect of preheating of nanocomposites with two different heating devices on the film thickness (FT) and flow (FL) properties of the materials.

Materials and Methods: Three resin composites [Filtek Supreme Ultra (FSU), Esthet X HD (EHD), Herculite Ultra (HLU)] were used in this study. The samples (n=15) were prepared either at room temperature (23°C), or preheated using a Calset™ (68°C) (AdDent Inc., Danbury, CT, USA) or POMO (70°C) (B&L Biotech, USA) devices. The composite resins were placed between two strip-covered glass plates and a load of 15 kg was applied vertically to the glass plates for a period of 180 seconds. The composite materials were then light-cured and the thickness measured using a micrometer. Three measurements were made on each polymerized specimen and then averaged. To investigate flow properties, each sample was photographed and the surface area was calculated.

Results: Preheating decreased film thickness and increased flow of composite resins. However, no significant differences have been found between the composite resin groups and heating devices (Table 1).

	Room Temperature		**Calset™**		**POMO**	
	FT (mm)	**FL (mm^2)**	**FT (mm)**	**FL (mm^2)**	**FT (mm)**	**FL (mm^2)**
FSU	0.13±0.01	2.38±0.09	0.10±0.01	3.29±0.15	0.09±0.01	3.02±0.10
EHD	0.10±0.01	2.62±0.17	0.08±0.01	3.54±0.28	0.08±0.01	3.67±0.26
HLU	0.10±0.01	2.95±0.18	0.08±0.01	3.30±0.09	0.08±0.01	3.83±0.15

Table 1: Film thickness values

Conclusion: Preheating of composite resins may allow easier placement and better adaptation of resin material to the cavity walls. Both of the heating devices can be used to increase flow properties of resin composites.

Funding/Conflict of Interest: None.

Keywords: film thickness, flow, resin composite

L22: Laboratory Research, Junior Scientist

Effect of Preheating on the Bonding Performance of Composites

Zeynep Batu[a]*, Fusun Ozer[b], Brian Lee[b], Nihar Pillai[b], Markus B. Blatz[b]

[a]Faculty of Dentistry, Istanbul Aydin University, İstanbul, Turkey
[b]School of Dental Medicine, University of Pennsylvania, Philadelphia, PA, USA

Purpose: The aim of this study was to investigate the effect of different preheating devices on the bonding performance of composite resins to dentin surfaces in Class I cavities.

Materials and Methods: 54 third molar teeth were randomly divided into 3 groups according to resin composite applied; Filtek Supreme Ultra (FSU), Esthet X HD (EHD), Herculite Ultra (HLU). Box-shaped Class I cavities (4x4x2) were prepared in the midcoronal dentin and a self-etching bonding agent (Clearfil SE Bond, Kuraray, Japan) was applied. Before being placed in the cavities, the resin composites (n=6) were either kept at room-temperature (23°C) or previously preheated with one of the heating devices; Calset (68°C) (AdDent Inc., Danbury, CT, USA) or POMO (70°C) (B&L Biotech, USA) according to the companies' instructions. The restored teeth were stored in distilled water at 37°C for 24h and then vertically sectioned to obtain 1.0mm2 cross-sectional composite-dentin beams. Microtensile bond strengths (µTBS) were measured at a crosshead speed of 0.5mm/min. The data were analyzed by two-way ANOVA and Tukey's test.

Results: There were no statistically significant differences between the groups at room temperature (Table 1). Although preheated FSU with Calset had highest bond strength, both heating devices did not significantly increased bonding performance of the composite resins.

Mean µTBS values of the groups [MPa]			
Groups	**Room Temperature**	**Calset**	**POMO**
FSU	30.6 ± 7.5^{ab}	34.1 ± 8.1^{b}	30.1 ± 6.74^{a}
EHD	30.6 ± 7.8^{ab}	29.0 ± 6.9^{a}	29.2 ± 5.78^{a}
HLU	30.17 ± 6.6^{ab}	30.3 ± 7.4^{ab}	32.3 ± 7.08^{ab}
* Differences in the letters indicate statistical significance ($p<0.05$).			

Table 1: Micro-tensile bond strength values

Conclusion: Preheating of the composite resin materials did not affect bonding performance to dentin surfaces in Class I cavities. Keeping the materials in room temperature was good enough to obtain optimum bonding performance.

Funding/Conflict of Interest: None

Keywords: preheated composite, bond strength

C23: Clinical Research (*withdrawn*)

Fiber-reinforced Composite Base for Large Posterior Restorations: One-year Report

R. Banu Ermis[a]*, Muhittin Ugurlu[a], Bart Van Meerbeek[b], Marleen Peumans[b]

[a]Suleyman Demirel University, Isparta, Turkey
[b]KU Leuven, Leuven, Belgium

Purpose: Fibre-reinforced composite designed to replace dentin in large posterior cavities as a base filling material may provide a durable foundation for composite restorations. The objective of this randomized controlled clinical trial (RCT) was to test the hypothesis that extensive composite restorations with a fiber-reinforced base perform equally well as composite restorations without this base (control).

Materials and Methods: Using a paired-tooth study design, 40 patients (38 females and 2 males, age range of 19-54 years) received one pair of restorations. Each cavity in the pair was randomly assigned to receive a conventional micro-hybrid composite (G-aenial Posterior, GC) with a fiber-reinforced composite base (ever-X Posterior, GC) or solely the conventional composite (control). The mild two-step self-etch adhesive (Clearfil SE Bond, Kuraray Noritake) applied with selective enamel etching was used in both groups. The restorations were evaluated at baseline (one week after treatment), and after 6 and 12 months of clinical service by two examiners. The parameters regarding functional, biological and esthetic properties were evaluated in accordance with the FDI clinical criteria.

Results: At one year, 74 restorations were evaluated (93% recall rate). All restorations were still present. Both groups demonstrated good color match and translucency. None of the restorations were affected by postoperative sensitivity, secondary caries or restoration fractures. Minor marginal discoloration was detected in a few patients. Regarding tooth integrity, no hairline cracks or marginal enamel or cusp fractures were observed. After one year, small but clinically acceptable marginal defects were recorded in about 50% of the restorations in both groups. Also, small material chip fractures were detected in five patients. No significant differences were found between both groups for all parameters evaluated (Chi-square analysis, $p>0.05$).

Conclusion: At one year, both the composite restorations with and without a fiber-reinforced base were considered clinically acceptable when applied to restore extensive Class-II cavities.

Funding/Conflict of Interest: None.

Keywords: class-II cavities, fibre-reinforced composite, randomized controlled clinical trial

C24: Clinical Research, Student Scientist

Clinical Performance of All-Ceramic Dental Restorations

Mariam Vonderheide[a]*, Julian Conejo[a], Markus Blatz[a], Reto Nueesch[b]

[a]School of Dental Medicine, University of Pennsylvania, Philadelphia, PA, USA
[b]University of Zurich, Zurich, Switzerland

Purpose: To assess the current scientific evidence on the clinical performance of all-ceramic dental restorations.

Materials and Methods: A MEDLINE (PubMed) and Cochrane Library search from October 2013 to October 2016 was conducted for English language articles in dental journals by two reviewers. Clinical studies meeting the following criteria were included: 1) studies related to restorations made of feldspathic ceramic, hybrid ceramic, silicate ceramic, and oxide ceramics; 2) prospective, retrospective, or randomized controlled trials conducted in humans; 3) studies with a follow-up of 5 years. For this purpose, Mesh terms and free text words were used: clinical, dental prosthesis, dental restoration, dental implant, implant supported restoration, crown, fixed dental prosthesis, dental veneers, inlay, onlay, ceramic, resin-based material, zirconium, zirconia, zirconium oxide, and porcelain. The filters applied were: publication date from 2013/10/01 to 2016/10/01; English language. A specialized librarian supported the literature search. Finally, the electronic search was complemented by a manual search. All titles obtained were screened for additional relevant clinical studies.

Results: The electronic database search revealed 991 titles. Full-text screening was carried out for 72 studies, yielding 57 articles that complied with the inclusion criteria (Figure 1). From the final 57 articles selected, the specific ceramic material, restoration type, mean follow-up, and number of patients were analyzed. The great inhomogeneity of the studies and variety of applied materials and methods did not allow for statistical assessment through meta analyses.

Figure 1. Search strategy

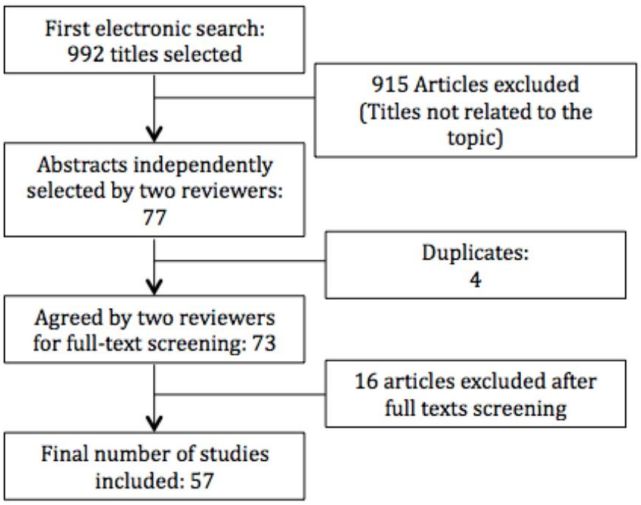

Figure 1: Search strategy

Conclusion: Silica-based feldspathic, leucite-reinforced, and lithium disilicate ceramics have high success rates for single-unit partial- and full-coverage restorations. However, adhesive cementation is needed to maximize their outcomes. Among oxide ceramics, alumina demonstrates high success rates, especially for single-unit anterior and posterior restorations and cantilever RBFDPs. Zirconia reveals high success rates for various restoration designs, such as anterior and posterior tooth- and implant-supported SC, FDPs, and RBFDPs. Full-arch screw-retained implant-supported fixed dental prostheses and implant abutments are reliable. However, recent RMC, silicate, and oxide-based ceramics lack clinical scientific validation.

Funding/Conflict of Interest: None

Keywords: dental ceramics, dental restorations, clinical longevity, clinical application

C25: Clinical Research, Student Scientist

Clinical Performance of Monolithic Zirconia Veneers: A Systematic Review

Alexa Schweitzer[a]*, Julian Conejo[a], Markus Blatz[a]

[a]School of Dental Medicine, University of Pennsylvania, Philadelphia, PA, USA

Purpose: The aim of this systematic review was to assess the clinical performance of monolithic zirconia as a material for laminate veneers.

Materials and Methods: An electronic database search (Pubmed Plus, Cochrane, Embase) was conducted from January 2000 to October 2016 for clinical studies pertaining to monolithic zirconia veneers. This systematic review included only prospective case-control studies published in the English language dealing with the clinical outcome of monolithic zirconia veneers. Case reports were not included. Study selection, data extraction and risk of bias assessment was performed by two independent reviewers.

Results: The search strategy returned 947 studies between the three databases, of which 13 fit the inclusion criteria for full-text assessment based on title and abstract screening. After removal of duplicates, seven articles remained. Of the seven that were reviewed in full, zero fit the final inclusion criteria because none were clinical studies.

Conclusion: The use of monolithic zirconia for fabrication of porcelain veneers is not well documented in the literature. Before clinical use, more studies must be carried out. Clinical Significance: There is insufficient evidence to support the use of monolithic zirconia for the fabrication of laminate veneers over other widely-used materials such as feldspathic porcelain or lithium disilicate.

Funding/Conflict of Interest: None.

Keywords: zirconia, zirconium oxide, yttria stabilized tetragonal zirconia, Y-TZP, veneer, veneers, laminate, laminates

C26: Clinical Report, Clinician Award

Minimally Invasive Lithium Disilicate Pressed Restorations Utilizing 3D-Printed Patterns

Edward Chaoho Chien[a]*, Yuko Otsubo[a], Mohammad Hossein Dashti[a], Arthur Sun[a], Dan Nathanson[a]

[a]Henry M. Goldman School of Dental Medicine, Boston University, Boston, MA, USA

Purpose: Additive manufacturing, or three-dimensional printing (3D Printing), has become increasingly important in modern minimally invasive dentistry. Digital images generated from an intraoral or laboratory scanners are imported into designing software to generate a stereolithographic (STL) file, which can then be used for subtractive (milling) or additive manufacturing.

Case Report: This complex full mouth rehabilitation of a 45 years old female involves different stages of treatment combining 3D Printing, conventional techniques, and milling technology. Cusp tips of both mandibular canines (teeth #22 and 27), which were worn down by attrition, were restored by partial veneers to reestablish their form and function. These “no-preparation” veneers were designed digitally, wax patterns were 3D-Printed (VarseoWax CAD/CAST, BEGO), verified both on the stone cast and intraorally, and pressed into lithium disilicate glass ceramic (IPS e.max Press, Ivoclar Vivadent Inc.). The cementation process was carried out by first using the try-in paste of value -2 (Variolink Veneer, Ivoclar Vivadent Inc.) and then total etching under rubber dam isolation and, final cementation with resin cement (Variolink Veneer, Ivoclar Vivadent Inc.). Group-function occlusion was verified by an 8-micron foil (Shimstock metal foil, Coltene Whaledent) and the restorations were refined and polished using intraoral lithium disilicate polishing kit (Brasseler, USA).

Results:

Conclusion: This clinical report has shown one of the current potentials of stereolithographic technology; to generate partial veneers as pressable patterns with ease of handling, and thus achieving the goals of minimally invasive adhesive dentistry, through synergizing digital and conventional techniques.

Funding/Conflict of Interest: None

Keywords: printing, three-dimensional, lithium-disilicate, dental veneers, resin cements

C27: Clinical Report, Clinician Award

Semi-Direct Class V Restorations to Treat Non-Carious Cervical Lesions (NCCLs): A Case Report

Zainab Alsadah[a]*, Amr Azhari[a], Luana Oliveira-Haas[a]

[a]College of Dental Medicine, Nova Southeastern University, Fort Lauderdale, FL, USA

Purpose: Restoration of non-carious cervical lesion (NCCL) is a common occurrence in clinics. Deciding whether or not to restore or perform periodontal grafting procedures remains subjective and controversial among clinicians. Lesion depth, sensitivity, complicated home care, and patients' desire to improve his/her esthetics all are key factors that help in making the decision to restore the lesions, graft or just monitor them. Objectives: This work aims to help dentists in choosing the best treatment strategy, which necessarily involves steps of problem identification, diagnosis, etiological factor removal or treatment, and, if necessary, restoration. Objectives: This work aims to help dentists in choosing the best treatment strategy, which necessarily involves steps of problem identification, diagnosis, etiological factor removal or treatment, and, if necessary, restoration.

Case Report: A 51-year-old-male, presents with complaints about root sensitivity and esthetic concern about his maxillary and mandibular cervical lesions. Cavitation was involved the clinical crown with minor root exposure. Therefore, adhesive restorations were recommended. Semi direct heat treated composite inlays (Vit-l-escence, UltraDent) were fabricated for his maxillary non-carious cervical lesions (NCCLs) then cemented with flowable composite (3M ESPE). While the mandibular NCCLs were restored with direct composite restoration (Vit-l-escence, UltraDent).

Results: Sensitivity were dramatically decreased and patient was very happy with the esthetic outcome. Moreover, it was found that semi direct resin inlays minimize the shrinkage problem and allow for more control over contour and marginal leakage but require a greater length of time for preparation and placement in comparison with the direct system.

Conclusion: Non-carious cervical lesions are highly prevalent and may have different etiologies. Regardless of their origin, restoring these lesions can pose clinical challenges, including access to the lesion, field control, material placement, marginal finishing, patient discomfort, and chair time. However, semi direct resin inlays facilitate greater operator control over the final anatomical and color outcome. Furthermore, heat and pressure treatment for the composite can enhance the physical properties and the clinical behavior of the finished composite restorations due to increased monomer conversion.

Funding/Conflict of Interest: None.

Keywords: esthetic zone, cervical lesions, heated composite

C28: Clinical Report, Clinician Award

Direct Flowable Restorations Utilizing Injection Technique: The Digital Approach

Saro Atam[a]*, Zeynep Batu[b], Fusun Ozer[a], Hiroyuki Miyajima[a]

[a]School of Dental Medicine, University of Pennsylvania, Philadelphia, PA, USA
[b]Faculty of Dentistry, Aydin University, Istanbul, Turkey

Purpose: The digital evolution in the dental field provides remarkable diagnostic and designing tools for successful aesthetic results. The injection technique, incorporating new restorative materials with improved physical properties, is a novel treatment modality to create direct composite veneers as definitive restorations. The innovative approach of combining digital technology and injection technique was used in this case to treat malpositioned lateral incisors with predictable esthetic outcome.

Case Report: A 27 years old male patient presented with esthetic concerns related to stained defective class III composite restorations on teeth #8 and #9, and lingually positioned lateral incisors #7 and #10. Medical and dental history, clinical examination, diagnostic intramural scanning with Cerec (Sirona) and photographs obtained to provide data for a proper diagnosis and treatment planning. The treatment plan included four anterior composite veneers on teeth #7,8,9 and 10. A 3D printed model was fabricated after digital smile design analysis, and digital wax-up. Clear, Vinyl Polysiloxane material was used to create the transparent injection matrix. Minimal teeth preparation was performed and verified with a reduction matrix. After tooth etching and bonding. flowable resin composite was injected through the transparent matrix and it was light-cured with the matrix in place. Each tooth was boned separately.At the end, excess was removed and polishing was done with polishing paste and finishing discs.

Results: The permanent direct flowable restorations satisfied the patient's esthetic expectations. Flowable composite has excellent handling, finishing, and polishing properties that resulted in highly aesthetic and natural outcome.

Conclusion: The direct flowable composite technique provides treatment that is minimally invasive, time-efficient, and cost-effective. When combined with digital technology the results are predictable and the process more efficient than when combined with conventional techniques. The future clinical applications of the injection technique along with the immense potentials of digital technology may provide clinical with alternative approaches to various clinical situations while allowing them to deliver predictable and minimally invasive dental treatment to their patients.

Funding/Conflict of Interest: None.

Keywords: injection technique, direct restorations, flowable, bonding, CAD/CAM

C29: Clinical Report, Clinician Award

Repair of Dental Restorations – a Reliable Clinical Procedure

Anne-Katrin Lührs[a]*

[a]Hannover Medical School, Hannover, Germany

Purpose: The repair of dental restorations has many advantages over the replacement of a restoration: first of all, the treatment is minimal invasive, furthermore, there is less danger of pulpal damage and very often a more invasive treatment such as the placement of a crown can be retarded. Despite low annual failure rates of composite, amalgam, cast and ceramic restorations, some failures might occur during clinical service. Before repairing a restoration, it is important to determine why a failure occured in the first place. If repair is preferred over a new restoration, questions arise regarding the ideal repair procedure.

Case Report: As many different materials for restoring teeth exist, numerous repair procedures can be applied, for example for the repair of composite, cast or ceramic restorations. The most important treatment step is, independent of the material to be repaired, the mechanical pre-treatment of the restoration surface. After complete caries removal, the repair is performed preferably with adhesively bonded composite. Different clinical cases illustrate repair procedures "step by step" for composite, amalgam, cast and ceramic restorations, for example after restoration fracture, secondary caries or marginal leakage.

Results: All presented clinical cases show that if caries can be removed completely during restoration repair, the life-span of the existing restoration can be extended while preserving healthy tooth tissues.

Conclusion: Although the amount of literature regarding the repair of dental restorations in vivo is very limited, repaired restorations have a good clinical prognosis. However, the long-term stability also depends strongly on the reason of the primary failure. Secondary, the complete removal of caries is a "condition sine qua non" for applying repair protocols successfully. Taken together, the repair of restorations is an accepted and reliable clinical procedure.

Funding/Conflict of Interest: None.

Keywords: dental restoration repair, composite resins, dental bonding, silanes