## Abstract #1

Influence of layer thicknesses on color in two composite concepts

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**Objectives**: For good esthetics of dental restorations the optical properties of teeth are mimicked by composite stratification in an opaque layer (Dentine) and a translucent layer (Enamel). Most contemporary layered composite systems are available in two basic concepts: 1. Dentine and Enamel have the same shade for a particular shade-code (corresponding with Vita Classical guide) and a different translucency level; 2. Dentine and Enamel have different shades where Enamel is always highly translucent. The shades of the latter sometimes correspond with Vita but sometimes employ a uniquely developed shade concept. The objective was to evaluate the influence of the thickness of the Enamel and Dentine layer on the shade distribution in two different layering concepts.

**Materials**: The composites tested were: Concept 1. Clearfil Photo Bright (Kuraray), Herculite XRV Ultra (Kerr) and Venus Diamond (Heraeus Kulzer); Concept 2. Amaris (VOCO), CeramX Duo (DENTSPLY) and Point4 (Kerr). In order to standardize thicknesses of composites a poly-acrylic mold with teflon cover was designed and samples of wedge-like dimensions (H=from 0 to 1.2mm, W=10, L=15mm) were produced. Total of 36 samples (two samples per shade: A1, A2 and A3, per composite) were made. The L*a*b* values represent the average of spectral data collected from three areas along the wedges: T1=0-0.4mm, T2=0.4-08 and T3=0.8-1.2. Student T-tests revealed significance levels between the average $\Delta E$ values of T1, T2 and T3 for each composite. The clinical relevance was set at $\Delta E \geq 3.7$ (acceptability threshold).

**Results**: Statistically significant differences ($p<0,05$) were found for all thicknesses and for all shades between two composite concepts using a black background. The concept 2 composites showed more clinically relevant variation in $\Delta E$ with increased thickness than the concept 1 composites, except for Point4.

**Conclusion**: The concept 2 composites are more color-sensitive to thickness changes, which implicates less predictability in a daily clinical routine.

## Abstract #2

Colorimetric evaluation of  flowable resin composite

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***Objective:*** The purpose of this study was to evaluate the optical properties(CIELab and TP values) of flowable resin composites compare from standard resin composite over commonly used two backgrounds.

***Methods:*** Three flowable resin composites (Filtek™ Supreme Ultra Flow(UF) (3M ESPE), MI Flow (MF)(GC), Estelite Flow Quick(EF)(Tokuyama Dental)) and two hybrid resin composites (Estelite P Quick (EP)and Estelite Sigma Quick(ES)(Tokuyama Dental))were used in this study. Three shades(A1, A2, A3) of cured resin composite dicks after polishing with 600-, 800- or 1200- grit SiC paper were measured according to the CIELAB color scale relative to the illuminant D65 on white background and black background. Spectra Scan PR650 non-contact spectrophotometer (Photo Research, USA) was used to perform colorimetry under D65 lighting, 1000 lux illuminance, and illumination from 45º to 0º light reception. Specimens were fabricated 0.5 mm thickness. Color (L*,a*,b*) , TP(Translucency parameter)  were calculated.

***Results:*** Means and standard deviations for L*,  a*,  b*  values on white backgrou nd and  TP values of resin    composite(A1)are listed.

| | L* | a* | b* | TP |
|---|---|---|---|---|
| UF | 94.7(0.1) | -1.6(0.0) | 14.9(0.0) | 39.2(0.2) |
| MF | 95.4(0.3) | -2.2(0.0) | 16.0(0.3) | 36.9(0.7) |
| EF | 93.5(0.3) | -2.0(0.0) | 32.0(0.3) | 40.2(0.6) |
| EP | 94.8(0.2) | -3.7(0.0) | 18.9(0.2) | 33.3(0.2) |
| ES | 93.6(0.2) | -1.6(0.0) | 19.9(0.2) | 37.9(0.4) |

***Conclusion:*** Two(EF, UF) of flowable resin composite exhibited greater TP values than standard resin composites ($p<0.05$). Knowledge of the relative translucency of different commercial materials can assist clinicians in the choice of composite for c linical use.

# Abstract # 3

## COLOR EVALUATION OF COLORED ZIRCONIA STRUCTURES COMPARED TO HUMAN DENTIN

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**Objectives:** All-ceramic restorations have been recommended to achieve superior esthetics in dentistry and the the Zirconia system is used as a sub-structure for these restorations. One of the main features of this system is the option of coloring its materials to improve ceramic core color. The purpose of this in vitro study was to evaluate the color of zirconia copings for single crowns fabricated with different CAD/CAM systems, using human dentin as control.

**Methods*:*** Two polycristal stabilized zirconia systems were evaluated: 3 variants of **IPS e.max ZirCAD®** (*Ivoclar Vivadent*): Sintered regular samples (ZC1), colored (colouring liquid CL1) and sintered samples (ZC2), and sintered samples of pre-shaded blocks MO1 (ZC3); and 2 variants of **LAVA™** (*3M ESPE*): Sintered regular samples (LV1) and colored (colouring liquid FS3) and sintered samples (LV2). 5 discs (0,5mm thick) per group (after sintering) were prepared. Color parameters were calculated from diffuse reflectance measurements against a black background using a spectroradiometer and a source simulating the D65 illuminant (d/0º; 2º CIE Standard Observer). Color differences ($\Delta E^*_{ab}$ and $\Delta E_{00}$) between medial superficial human dentin (DHSM) and stabilized Zirconia systems were calculated. Kruskal-Wallis and Mann-Whitney tests were applied.

**Results:** Table shows the values obtained for L*,a*,b*, Chroma and Hue angle ($h^0$) for all materials evaluated. For Lightness, significant differences ($p<0.001$) were found between DHSM and all Zirconia systems. The values obtained for all the chromatic coordinates for the studied materials are showing that this restoration material is more achromatic than the control human dentin, generally showing statistically significant differences for all comparisons. All the calculated color differences exceeded the perceptibility and acceptability color thresholds for dentistry. ZC2 system showed the greatest similarity with the human dentin.

| | DHSM | ZC1 | ZC2 | ZC3 | LV1 | LV2 |
|---|---|---|---|---|---|---|
| **L*** | 73,33(2,25) | 79,47(1,25) | 79,95(1,26) | 83,51(1,16) | 89,81(0,89) | 85,92(1,41) |
| **a*** | -2,10(0,23) | -0,83(0,07) | -2,18(0,19) | -1,75(0,44) | -0,44(0,09) | -0,01(0,10) |
| **b*** | 9,14(1,20) | -1,33(0,11) | 7,37(0,40) | 2,46(0,51) | -2,86(0,06) | 8,83(0,79) |
| **C*** | 9,39(1,12) | 1,56(0,11) | 7,69(0,41) | 3,06(0,46) | 2,90(0,06) | 8,83(0,79) |
| **$h^0$** | -1,34(0,05) | 1,01(0,04) | -1,28(0,02) | -0,95(0,17) | 1,42(0,03) | 0,01(1,63) |
| **$\Delta E^*_{ab}$** | - | 12,25(0,56) | 6,86(1,27) | 12,21(0,97) | 20,56(0,88) | 12,79(1,54) |
| **$\Delta E^*_{00}$** | - | 10,09(0,32) | 4,93(0,88) | 8,96(0,66) | 15,59(0,50) | 9,20(0,96) |

**Conclusions*:*** Within the limitations of this study, in terms of colorimetric characteristics, ZC2 presented a good similarity with the evaluated human dentin.

## Abstract # 4

The role of the instrumental shade selection - Clinical study

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**Objective**- to assess the importance of instrumental methods in shade selection on the quality of the clinical results in the case of direct and indirect esthetic restorations

**Material and methods**. A total of 54 anterior teeth were restored by direct composites (40 teeth) (Filtek Ultimate- 3M Espe) and indirect methods (10 teeth with Vita Inceram Alumina full ceramic crowns and 4 teeth with feldspathic ceramic veneers).

In each case the shade was assessed by two methods: spectrophotometrical (Vita Easyshade Vita) and then visual ( Vitapan Classical for direct restorations and 3D Master or 3D Master Linear Guide for indirect restorations). In addition, for indirect restorations, dental technician was provided with digital images of the prepared teeth and corresponding selected shade tabs.

The esthetic result was assessed by both the clinician and the patient and included in three groups: acceptable, good, excellent.

**Results**. For indirect restorations, the shade used was in 65% of the cases the one indicated by the spectrophotometer; in 35% , it was adjusted by visual assessment for at least one area. For 57.14% of the indirect restoration the final shade was indicated by the instrument, in 42.86% of the cases it was modified after the visual analysis

When final result was evaluated, the operator indicated 62.5% of the direct restorations as excellent, 25% as good and 12.5% as acceptable while the patients appreciated them as excellent ( 90%) and good (10 %) . For the indirect restorations, 71.42% were indicated by the clinician as excellent, 7.14% as good and 21.42% as acceptable, while the patients described 78.57% of the restorations as excellent and 21.43% as good.

**Conclusions** For better results, the instrumental result in the shade selection is associated with visual analysis. The clinicians are often more critical in the assessment of the final results regarding color matching than the patients.

Sponsored by Vita Zahnfabrik and 3M ESPE

# Abstract # 5

Color Effects of Gingiva on Cervical Regions of All-Ceramic Crowns

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*Objectives:* The final color of all-ceramic crowns is impacted by the color of the remaining tooth structure as well as the surrounding gingival tissue. The optical effect of gingival tissue on an all-ceramic crown has never been fully studied. The purpose of this study is to investigate the effects of gingival color on ceramic crowns in the cervical region.

*Methods:* Thirty-one all-ceramic crowns of differing shades were included in this study. Using a spectrophotometer, we measured the color values of each crown on a typodont in the absence of an artificial gingiva (control group) as well as in the presence of an artificial gingiva (test group). CIELAB color coordinates ($L^*$,$a^*$,$b^*$) were collected from three regions of the cervical area in descending order from the gingival margin (upper region, middle region, and lower region) for each group. Color difference values $\Delta E$ were calculated for each cervical region in each of the two groups. The color difference $\Delta E$ between the test and control groups from upper to lower cervical regions was also assessed. The statistical analysis was performed using the Wilcoxon signed-rank test.

*Results:* The median $\Delta E$ values between the test group and control group at the upper, middle and lower cervical regions were 5.7, 2.6 and 1.7 respectively. Significant color differences were detected in the upper and middle regions ($p<0.00001$ at $\Delta E = 2$ threshold); all color coordinates ($L^*$, $a^*$, and $b^*$) contributing significantly to the color differences in the two regions ($p<0.0001$). The color variations in the cervical area also varied significantly from the upper region to the lower region, with $L^*$, $a^*$ contributing most to the differences.

*Conclusions:* The presence of artificial gingiva is a critical factor for precise color matching of all-ceramic crowns.

## Abstract # 6

Repeatability of four dental shade-matching instruments

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**Objectives:** Electronic shade-matching instruments are becoming more popular for clinical use and may improve the accuracy and reliability of tooth color determination.

The objective of this *in vivo* study was to evaluate the intra- and inter- device repeatability for different tooth locations using four color measurement devices under clinical conditions.

**Methods:** The color of all maxillary anterior teeth of 20 dental students without any restorations, fillings or irregular surface morphology was evaluated. Therefore each tooth (6-11) was measured five times at the central region with each device under standardized conditions. The examinated dental shade matching devices represent a selection of commercially available products and were selected in consideration of the different measurement methods and geometry used (DeguDent Shade Pilot/SP, Olympus CrystalEye/CE, VITA Easyshade compact, X-Rite Shade Vision/SV). The color data were generated as CIE L*a*b* values. Intraclass correlations coefficients (ICCs) were used to statistically analyze intra- and inter-device repeatability for different tooth locations. Color differences (ΔE) were calculated to evaluate the clinical acceptability.

**Results:** The four color measuring devices exhibit a clinically acceptable repeatability for all tooth locations, with an average ICC of 0.9734 (ΔE = 0.53) for SP, 0.9823 (ΔE = 0.41) for CE, 0.9226 (ΔE = 1.92) for ES and 0.8463 (ΔE = 1,25) for SV device. The interdevice repeatability was low, with an average ICC of 0.5944 (ΔE = 3.85) between SP/CE, 0.4415 (ΔE = 6.49) between CE/ES, 0.4289 (ΔE = 7.27) between ES/SV, 0.4201(ΔE = 6,40) between SP/ES, 0.6944 (ΔE = 3.46) between SP/SV and 0.5768 (ΔE = 3.52) between CE/SV.

**Conclusion**: Each device shows a good clinical color match independent of the tooth location. The absolute CIE L*a*b* values of each measurement device differ from each other with a clinical unacceptable color difference (ΔE > 3.5). Our results demonstrate a high repeatability, but a lack of comparability of CIE L*a*b* values between dental color measurement devices.

## Abstract # 7

# Evaluation of Color Stability within an All Ceramic Monolithic system

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**Objectives**: The aim of this study was to determine by means of a clinical spectrophotometer the ability of an all ceramic system (e.max CAD LT/HT, Ivoclar Vivadent, Ellwangen, Germany) to precisely reproduce the CIE L*a*b* color coordinates of identical color designations. We tested the null hypothesis that no significant difference existed between the CAD/CAM-fabricated all ceramic crowns.

**Methods:** A total of 30 all ceramic full crowns (right middle maxillary incisor) were fabricated with a CAD/CAM System (Cerec AC acquisition unit and CEREC 3 MC XL milling unit, Sirona, Bensheim, Germany) using an IPS e.max CAD LT (15 crowns) and HT (15 crowns) ceramic bloc. All crowns were inserted with two different Variolink try-in pastes (yellow A3/ transparent). The color was measured ten times with a color measurement device (Shade Pilot, DeguDent, Hanau, Germany) under standardized conditions. The color data were generated as CIE L*a*b* values. Color differences (ΔE) were calculated and the oneway-ANOVA (SPSS GmbH Software, München, Germany) was used to compare the results among the crowns.

**Results**: Following mean color differences (ΔE) were evaluated: e.max CAD LT/A3= 0.7809 (SD= 0.3095); LT/transparent= 0.3429 (SD 0.2040); HT/A3= 0.7144 (SD 0.2817); HT/transparent= 0.4708 (SD 0.2638); The results of ANOVA show a significant difference ($p < 0.05$) between the color coordinates of singular ceramic crowns.

**Conclusion:** Within the limitations of this in vitro study we can conclude that the IPS e.max CAD ceramic system is able to consistently reproduce CIE L*a*b* color coordinates with a perfect to excellent clinical compliance (ΔE LT/HT= 0-1). Further studies are required to point up these results.

# Abstract # 8

SHADE COLOR DIFFERENTIATION WITH PRINCIPAL COMPONENT ANALYSIS

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**Objectives:** Conventionally, 3-dimensional color spaces such as *RGB*, *XYZ*, *L*a*b**, *L*u*v**, and *L*C*h*, are used in practice in dental color assessment, even if hyper-spectral data are obtained by imaging devices. However, the original hyper-spectral data should be considered for the next stage of dental color assessment. Therefore, we analyzed hyper-spectral data measured by various shade guides based on principal component analysis (PCA), and discussed the effectiveness of hyper-spectral data for dental color assessment.

**Methods:** Two series of shade guides (Beautifil II, Shofu / Clearfil Majesty, Kuraray Medical) were illuminated with two artificial sunlight lamps (XC-100a, Seric) equipped with linear polarizers. Spectral data were acquired with a spectroradiometer (CS-2000, Konica Minolta). A circular polarizer (Zéta EX C-PL, Kenko) was set on the spectroradiometer to remove specular reflection. A black patch of the color chart (Muncell ColorChecker Classic, X-Rite) and the diffuse reflection standard (CS-A5, Konica Minolta) were used as the black and white backgrounds. Acquired data were standardized as spectral reflectance data. Then, reflectance data were weighted by luminous efficacy function, and used in PCA. Principal components (PCs) and their contribution, and values of respective shades to respective PCs were calculated as PC scores.

**Results:** Respective PCs showed specific figures, and values of shades showed sequences unique to each PC; values of the 1$^{st}$ PC showed gradual changes with change in shade numbering, values to the 2$^{nd}$ PC showed relatively high scores on opaque shade, values to the 4$^{th}$ PC showed lower scores on B and C group shades, and values to the 6$^{th}$ PC showed differences between resin composites.

**Conclusions:** Using PCA, we could find axes independent of the conventional 3-dimensional color spaces. These axes reflected certain changes that are not detected on conventional color spaces. Our proposed method would help to diagnose color differences of dental materials.

# Abstract # 9

A spectrophotometric analysis of the opacity of nanofilled composite

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**Objectives***:* In multi-layered esthetic restorations, composites of different gradations of opacity are used to replace the tooth structure. Although color is described by different shade models, there is no systematic description of opacity or translucency. Color measurement on black and white backgrounds of Filtek™ Supreme specimens were carried out to evaluate the opacity of these restoratives.

**Methods:** 45 specimens of the composite, in thicknesses of 1, 2, 3, 4, 5, 6, and 7 mm were prepared using custom-designed molds for shades A1, A2, A3 of the Dentin, Body, and Enamel colors; and 20 specimens were made of the shades Clear (CT), blue (BT), grey (GT) and Amber (AT) for Translucency. The specimens were measured three times with the Vita Easyshade Compact Spectrophotometer, against a black and white background. The mean L*a*b* values and Translucency Parameters (TP) were calculated. The threshold for acceptability used was 3.7.

**Results:** There was a decrease in translucency (TP) as the thicknesses of the specimens increased. The table shows the threshold of the specimens (in mm) where it is not possible to see the difference between a black and white background (ΔE<3.7). The Enamel and Body colors had a slower rate of decrease in translucency than the Dentin colors. Furthermore, in contrast to the Enamel and Body color, the translucency of the Dentin color is not dependent on the shade.

| | Enamel | Body | Dentine |
|---|---|---|---|
| A1 | 4.8 mm | 3.5 mm | 2.3 mm |
| A2 | 4.8 mm | 3.5 mm | 3.3 mm |
| A3 | 4.8 mm | 3.5 mm | 3.0 mm |

The color difference between specimens itself (the 7 mm specimen) and specimens with the thickness between 1-6 mm on a black and white background were also calculated. The ΔE of the specimens on a black background compared to their 7 mm specimens were very small. In contrast, the ΔE of the specimens on a white background compared to their 7 mm specimens were strongly dependent on the thickness of the specimen. The Translucency shades could not be evaluated as they could not be measured with this spectrophotometer.

**Conclusions:** From the results it can be concluded that a black background is easier to cover than a white background. Looking at the translucency of the shades A1, A2, and A3, it can be seen that the manufacturer has developed the shades consistently in order of decreasing translucency for the Body and Enamel colors, but the Dentin colors of this composite are less predictable for using in multi-layered esthetic restorations.

# Abstract # 10

Does positioning of a dental shade-matching instrument influence its precision**?**

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*Objectives:* Human teeth are polychromatic, varying in thickness and translucency. Therefore, controlled repositioning of color measuring device may influence the outcome in related studies, such as monitoring tooth whitening. The purpose of this *in vitro* study was to evaluate the effect of positioning method on precision of a dental shade-matching instrument.

*Methods:* Color of the middle labial portion of sixteen tabs from the VITA Classical shade guide (Vita Zahnfabrik) was measured using an intra-oral spectrophotometer (Vita Easyshade Compact, Vident). Measurements were performed with repositioning, 10 times for each tab using a custom positioning jig (CPJ) fabricated from clear silicone bite registration material, and 10 times using a free-hand technique (FHT). The precision of each method was calculated using the mean color difference from the mean (MCDM). For a set of CIELAB measurements, the average L* a* b* values were calculated, and $\Delta E^*_{ab}$ was determined between these mean values and L* a* b* values for each individual measurement. The average of these color differences was the MCDM for each shade. MCDM and standard deviations (s.d.) for each shade and a shade guides as a whole were calculated for both positioning methods. A unpaired t-test was performed.

*Results:* MCDM (s.d.) for the shade guide was 0.15 (0.11) for CPJ and 0.28 (0.20) for FHT. Corresponding values for each tab (ST) are listed in the table.

| ST | CPJ | FHT | ST | CPJ | FHT | ST | CPJ | FHT | ST | CPJ | FHT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| A1 | 0.22 (0.13) | 0.36 (0.20) | B1 | 0.12 (0.08) | 0.30 (0.15) | C1 | 0.14 (0.07) | 0.27 (0.11) | D2 | 0.08 (0.04) | 0.32 (0.15) |
| A2 | 0.13 (0.06) | 0.32 (0.26) | B2 | 0.13 (0.09) | 0.22 (0.13) | C2 | 0.06 (0.02) | 0.20 (0.15) | D3 | 0.17 (0.09) | 0.18 (0.12) |
| A3 | 0.12 (0.06) | 0.30 (0.28) | B3 | 0.10 (0.08) | 0.19 (0.11) | C3 | 0.11 (0.06) | 021 (0.21) | D4 | 0.23 (0.09) | 0.21 (0.12) |
| A3.5 | 0.24 (0.12) | 0.36 (0.11) | B4 | 0.10 (0.07) | 0.35 (0.25) | C4 | 0.15 (0.14) | 0.32 (0.18) | | | |
| A4 | 0.23 (0.14) | 0.45 (0.34) | | | | | | | | | |

The difference between CPJ and FHT was statistically significant ($p<0.0001$), with the CPJ showing lower MCDM values compared to FHT.

*Conclusions:* A method using a custom positioning jig resulted in significantly greater precision of color measurements of Vita Easyshade intra-oral spectrophotometer compared to free- hand technique. A custom position jig is recommended for repeated measurements in dentistry.

Acknowledgment: The authors thank VITA Zahnfabrik for donating Vita Easyshade Compact intra-oral spectrophotometer.

Disclosure: Dr. Paravina is paid consultant for VITA Zahnfabrik.

## Abstract # 11

Effect Of Ceramic Thickness And The Use Of Catalyst Of Resin Cements

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**Objectives**: Examine the curing efficiency of resin cements when luting ceramics of various composition and thickness.

**Methods**: Ceramic specimens (VITABLOCS Mark II, VITA), (Empress CAD, Ivoclar), (e.max CAD, Ivoclar) and (Paradigm MZ100, 3M ESPE) were prepared to a diameter of 4 mm and heights of 0.5, 1.0, 1.5, 2 mm. The ceramic specimens internal surface was etched and inserted in steel molds (diameter 4 mm, height 6 mm). A composite resin luting material (Calibra, Dentsply) with and without catalyst was placed following the manufactures instructions. Each group was conventionally light cured (Triad curing unit, Dentsply). Depth of cure under the ceramic specimens was assessed according to ISO 4049. Additionally, universal hardness was determined using a microhardness tester (Micromet II, Buehler).

**Results**: The use of a catalyst always produced a greater hardness and depth of cure.

**Conclusion**: The curing efficiency of resin cements is enhanced with the use of a catalyst. The convenience and potential esthetic benefit of light cure materials may out weight the catalysts effect when ceramic thicknesses are minimal.

# Abstract # 12
# OPTICAL CHARACTERIZATION OF COLORED ZIRCONIA STRUCTURES

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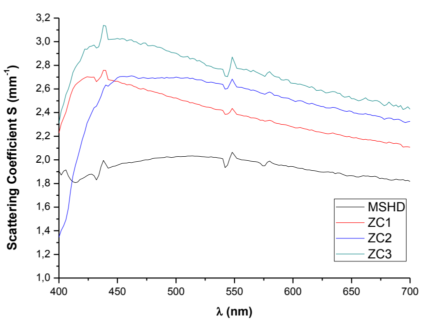
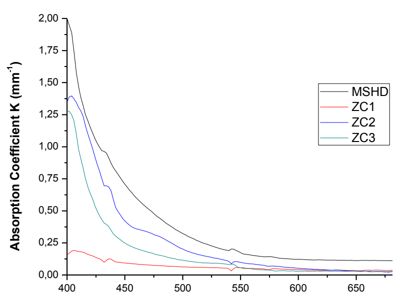
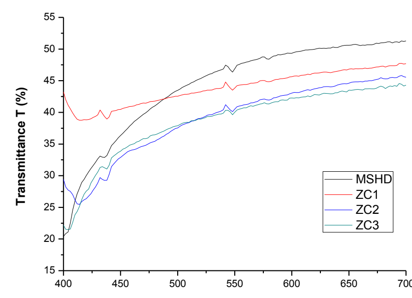
**Objectives*:*** The purpose of this study was to evaluate optical properties: scattering, absorption and transmittance of pre-sintered yttrium oxide stabilized zirconium oxide blocks for CAD/CAM technique, using human dentin as a control.
**Methods*:*** Three variants of **IPS e.max ZirCAD®** (*Ivoclar Vivadent*) system were evaluated: Sintered regular samples (ZC1); Colored (colouring liquid CL1) and sintered samples (ZC2); and Sintered samples of pre-shaded blocks MO1 (ZC3). All corresponding to A2/A3 shades, according to the Chromascop guide. 5 discs (0.5mm thick) of medial superficial human dentin (MSHD) and zirconia samples (after sintering) were prepared. Diffuse reflectance measurements were performed with a SpectraScan PR704 spectroradiometer; scattering (S), absorption (K) and transmittance (T) parameters were computed from the diffuse reflectance data applying the Kubelka-Munk´s equations. The obtained data were adjusted for every wavelength, using $K^*$ and $S^*$ as adjusting parameters, since they are related with absorption and scattering coefficients $K$ and $S$. Kruskal-Wallis, Mann-Whitney tests and VAF coefficient were applied.
**Results*:*** Although statistically significant differences ($p \leq 0{,}001$) were found when scattering was evaluated, the spectral behavior of the different groups was similar (VAF>99%). No differences between ZC1 and ZC3 were found for absorption, but they presented the lowest VAF values (75.60%) when all groups were compared. ZC2 had the higher VAF value (97.34%) when was compared with MSHD. A similar spectral behavior of the transmittance was found for all materials involved in this study (VAF>99%), showing a sharp increase for short wavelengths followed by a slight increase for medium and large wavelengths. No differences were found for this parameter when ZC1 and MSHD were compared. ZC2 and ZC3 showed no difference between them but they presented different behavior when compared to MSHD.




**Conclusions*:*** ZC1 presented optical properties similar to human dentin being therefore the most suitable for replacing this dental tissue.

# Abstract # 13

In-Vitro Assessment of Computer Color Matching for Zirconia All-Ceramic Crown

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**Objectives***:* Computer Color Matching (CCM) using the Kubekla-Munk theory has been considered the most effective color matching technique in the textile industry. A previous study (Kristiensen et al.) suggested that our prototype CCM program for ceramic restoration needed specifically organized shades to cover the entire tooth color spectrum with even color distribution. To address this issue, we have established 21 new shades that are evenly distributed over the entire tooth color spectrum. The purpose of this study was to test the use of these 21 new shades in conjunction with the CCM system to determine their ability to accurately reproduce the body color of 29 shade tabs from VITAPAN 3D Master.

**Methods:** 21 reference shades were prepared using Cerabien® CZR (Noritake) porcelain. Using manufacturer's instructions, we fabricated and then polished disks to a 1.0mm thickness. A spectrophotometer was used to measure the reflectance values from 380nm to 780nm for each disk; the scattering coefficient (S) and absorption coefficient (K) were determined. Using the reflectance values and the K/S coefficients, the CCM program generated prescriptions incorporating proportions from the 21 reference shades to reproduce the VITAPAN 3D Master shade tabs. Disks were fabricated from the prescriptions, polished to 1.0mm thickness, then placed over a zirconia core plate and measured with the spectrophotometer. The color differences ($\Delta E$) between VITAPAN shade tabs and corresponding ceramic disks were calculated. Statistical analysis was performed using the Wilcoxon signed-rank test.

**Results:** The median CIELAB $\Delta E$ between the target colors and the replicated colors is 1.28. The IQR (Q1, Q3) is (0.91, 1.58). Wilcoxon signed rank test for $\Delta E <= 2$ vs. $\Delta E > 2$ is significant with $p<0.0001$.

**Conclusions:** The Computer Color Matching system using the established 21 new shades is accurate and effective for reproducing tooth shades.

**Disclosure**: Dr. Shigemi Nagai received a research grant from Noritake Company.

# Abstract # 14

Color assessment of light-cured composite resins on different color charts

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**Objective**: With recent advances in adhesive systems, composite resins enable treatment based on the concept of minimal intervention dentistry. Also, esthetic repair is possible from the following day, even if the restoration is direct, provided the restoration is done properly. One important step in composite resin restoration is matching its color with natural teeth. In this study, we investigated the effect of background color on the color of composite resin, with reference to the color of natural teeth and discolored dentin to improve the match of composite resin restoration with the color of natural teeth.

**Methods:** Two commercially available types of composite resin, Filtek™Supreme Ultra (Ul) (3M ESPE, USA) and Filtek™Supreme XT (XT) (3M ESPE, USA), were used. Body shades (A2B, A3B) and dentin shades (A2D, A3D) common to both types were used. The resin materials were filled in plastic rings of internal diameter 8 mm, and light cured for 20 s each from both sides with a halogen-lamp curing unit (Astral). They were polished on the following day with waterproof abrasive paper (Buehler) #600, and after 24 h, with #800 and #1200 until a thickness of 1.0 mm was obtained. Five rings were prepared for each test material. Each test sample was placed on top of various background color boards, and a Spectra Scan PR650 non-contact spectrophotometer (Photo Research, USA) was used to perform colorimetry under D65 lighting, 1000 lux illuminance, and illumination from 45º to 0º light reception. The measurements were repeated five times in each sample. Colorimetry data were used to calculate L*, C*ab, and translucency parameter (TP) values on two types of color boards from CIELAB (N: L* value 70.03; a* value, 6.52; b* value, 31.19; and C: L* value, 53.7; a* value, 39.44; b* value, 36.59) and on a gray board with an L* value of 70 (G) as control, and the calculated values were compared.

**Results*:*** (1) L* values were in the range 70.2–77.8. With the exception of Ul**—**A3B on background C, all values exceeded the average L* value of natural teeth (L* value 70.56). (2) C*ab values were in the range 17.67–25.72. With the exception of Ul–A2B on background G, all values exceeded the average C*ab value of natural teeth (C*ab value 17.96). (3) TP values were in the range 17.33–27.13, with body shades exhibiting higher values than dentin shades for both UL and XT.

**Conclusions*:*** (1) Under these experimental conditions, brightness exceeding the average L* value can be obtained. (2) The chroma of composite resin was lower against a high-chroma background compared with a low-chroma one. (3) Dentin shades were less affected by the background in comparison with body shades. Dentin shades reportedly maintained higher chroma compared with body shades, but for A2 the C*ab value was higher for the body shade. (4) The chroma of the resin tended to be affected by the background color in different ways for different shades. Therefore, although it is important to match the brightness when checking the shade, performing careful chroma assessment would help to obtain a restoration that matches the color of the surroundings.

# Abstract # 15

Color Variations of the HeraCeram Zirkonia Veneering Ceramic

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**Objectives:** **:** The color reproduction process is important for the fabrication of artificial dentures. So far veneering ceramics are frequently used. The aim of this in vitro study was to determine the color differences of a veneering ceramic within different color categories under constant test conditions.

**Methods:** Six ceramic discs (HeraCeram Zirkonia. Heraeus Kulzer GmbH. Hanau. Germany) of each of the 16 colours of the VITA Classical system were produced using a hollow mould. CIE L*a*b* color coordinates of each of these discs were measured fivefold using the Vita Easyshade Advanced (VITA Zahnfabrik H. Rauter GmbH & Co. KG.. Bad Säckingen. Germany) spectrophotometer. The color variations were evaluated by calculating the color distances Δ E between the different discs within a series of “identical” color categories according to the following equation:

$\Delta E = [(L^*_i - L^*_{ii})^2 + (a^*_i - b^*_{ii})^2 + (a^*_i - b^*_{ii})^2]^{1/2}$. where i and ii represent two different measurements.

**Results**: The SD within the CIE L*a*b* color coordinates were in the range from 0.1 to 2.5. The mean color differences Δ E within the different color categories are in the range from 1.1 to 3.9 (Table 1).

| n | color | mean L | SD L | mean a | SD a | mean b | SD b | mean Δ E |
|---|---|---|---|---|---|---|---|---|
| 30 | A1 | 85.9 | 0.8 | 0.3 | 0.2 | 24.2 | 1.1 | 1.9 |
| 30 | A2 | 80.6 | 0.5 | 2.3 | 0.3 | 31.4 | 1.2 | 1.8 |
| 30 | A3 | 77.7 | 0.7 | 2.3 | 0.4 | 31.8 | 1.1 | 1.8 |
| 30 | A3.5 | 72.5 | 1.0 | 1.8 | 1.3 | 32.8 | 1.3 | 2.0 |
| 30 | A4 | 63.6 | 0.5 | 2.3 | 0.1 | 30.1 | 0.6 | 1.1 |
| 30 | B1 | 83.0 | 2.1 | 0.2 | 0.9 | 27.0 | 1.7 | 3.8 |
| 30 | B2 | 83.8 | 0.6 | 0.7 | 0.4 | 33.2 | 1.1 | 1.8 |
| 30 | B3 | 72.2 | 2.3 | 0.9 | 0.4 | 33.1 | 1.6 | 3.8 |
| 30 | B4 | 68.2 | 2.0 | 1.5 | 0.6 | 35.1 | 1.8 | 3.3 |
| 30 | C1 | 75.6 | 0.9 | 0.9 | 0.6 | 23.1 | 1.3 | 2.5 |
| 30 | C2 | 65.8 | 2.5 | 1.1 | 0.4 | 26.3 | 1.7 | 3.9 |
| 30 | C3 | 63.5 | 2.5 | 2.6 | 0.2 | 26.0 | 1.0 | 3.2 |
| 30 | C4 | 59.6 | 2.5 | 3.8 | 0.3 | 28.0 | 1.1 | 3.4 |
| 30 | D2 | 73.4 | 1.1 | 0.6 | 0.3 | 18.7 | 1.4 | 2.6 |
| 30 | D3 | 73.4 | 1.7 | 0.5 | 0.5 | 21.5 | 1.9 | 3.3 |
| 30 | D4 | 78.6 | 0.9 | 2.0 | 0.3 | 36.8 | 0.9 | 1.9 |

Conclusions: Within the limitations of this in vitro study color variations of the HeraCeram Zirkonia ceramic within the different colour categories of the VITA Classical system were detected. Color variations within the colour categories are partially detectable by human perception.

# Abstract # 16

Are Dental Color Measuring Devices CIE Compliant?

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Objectives: This in vitro study evaluated the accordance of dental color measurement devices with a Commission Internationale de l'Eclairage (CIE)-compliant reference system, by comparing the CIE lightness, chroma, and hue (L*C*h°) color coordinates of ceramic samples

Methods: Four color measurement devices, Vita Easyshade Advance (A), Degudent Shadepilot (B), X-Rite Shadevision (C) and Crystal Eye Olympus (D), were compared with a CIE-compliant reference system by recording the L*C*h° color coordinates of ceramic samples matching the tooth colors of the Vita Linearguide 3D-Master, under standardized test conditions. Differences between regression lines for the dental color measurement device data and regression lines for the CIE-compliant reference system data were evaluated.

Results: All devices offered high intraclass correlation coefficients (0.9771 to 0.9999) for the L*C*h° color coordinates. The regression lines of the L* and C* coordinates for device A were steeper than those for the CIE-compliant reference system; the regression lines for devices B, C, and D were nearly parallel to that for the reference system, but with an offset. The regression lines of the h° coordinates for all devices were almost parallel to that for the reference system, with slopes near 1. Excluding the L* and h° coordinate measurements of device A, the measurements with the devices exhibited deviations from the reference system that were greater than those expected by chance ($p<0.0002$).

Conclusions: The dental color measurement devices assessed here offered excellent reproducibility, but showed significant deviations from the CIE-compliant reference system with regard to the L*C*h° color coordinates.

# Abstract # 17

Color Variations of the IPS e.max Ceram Veneering Ceramic

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Objectives: Color reproduction process is a main aspect. So far veneering ceramics are frequently used. The purpose of this in vitro study was to determine the color differences of a veneering ceramic within different color categories under constant test conditions.

Methods: Six ceramic discs (IPS e.max Ceram, Ivoclar Vivadent AG, Schaan, Fürstentum Liechtenstein) of each of the 16 colours of the VITA Classical system were manufactured using a mould. CIE L*a*b* colour coordinates of each of these discs were measured fivefold spectrophotometrically using the Vita Easyshade Advanced (VITA Zahnfabrik H. Rauter GmbH & Co. KG., Bad Säckingen, Germany) spectrophotometer. The color variations were defined by calculating the color distances Δ E between the different discs within a series of "identical" color categories according to the following equation: $\Delta E = [(L^*_i - L^*_{ii})^2 + (a^*_i - b^*_{ii})^2 + (a^*_i – b^*_{ii})^2]^{1/2}$, where i and ii represent two different measurements.

Results: The SD within the CIE L a b* colour coordinates were in a range from 0.1 to 1.8. The mean colour differences Δ E within the different color categories were in the range from 1.1 to 2.4 (Table 1).

**Table. 1**

| n | color | mean L | SD L | mean a | SD a | mean b | SD b | mean Δ E |
|---|---|---|---|---|---|---|---|---|
| 30 | A1 | 82.8 | 1.0 | 0.9 | 0.5 | 27.0 | 1.4 | 2.4 |
| 30 | A2 | 76.3 | 1.0 | 3.0 | 0.3 | 30.5 | 1.2 | 2.2 |
| 30 | A3 | 75.1 | 0.5 | 4.4 | 0.1 | 35.6 | 0.6 | 1.1 |
| 30 | A3.5 | 71.3 | 1.0 | 6.1 | 0.5 | 40.8 | 1.5 | 2.3 |
| 30 | A4 | 68.0 | 0.7 | 7.4 | 0.2 | 40.5 | 0.6 | 1.2 |
| 30 | B1 | 81.8 | 1.1 | 0.3 | 0.3 | 20.6 | 0.9 | 1.9 |
| 30 | B2 | 79.3 | 1.2 | 1.4 | 0.1 | 27.9 | 0.5 | 1.7 |
| 30 | B3 | 72.5 | 1.0 | 4.4 | 0.3 | 39.9 | 0.4 | 1.5 |
| 30 | B4 | 71.4 | 0.6 | 6.0 | 0.3 | 43.4 | 0.6 | 1.3 |
| 30 | C1 | 72.4 | 0.7 | 2.1 | 0.1 | 22.6 | 0.5 | 1.3 |
| 30 | C2 | 70.0 | 0.6 | 1.9 | 0.2 | 27.9 | 0.7 | 1.2 |
| 30 | C3 | 68.7 | 0.6 | 2.7 | 0.3 | 29.5 | 1.2 | 1.8 |
| 30 | C4 | 60.1 | 0.6 | 5.9 | 0.6 | 33.1 | 0.8 | 2.0 |
| 30 | D2 | 77.0 | 0.9 | 0.8 | 0.5 | 19.3 | 0.4 | 1.5 |
| 30 | D3 | 75.7 | 1.6 | 1.9 | 0.2 | 25.5 | 0.9 | 2.3 |
| 30 | D4 | 72.1 | 1.2 | 1.9 | 0.2 | 32.3 | 0.5 | 1.7 |

Conclusions: Within the limitations of this in vitro study it was found that color variations of the IPS e.max Ceram ceramic within several color categories were partially detectable by human perception (Δ E > 1). However, the evaluated color differences within all color categories were clinically acceptable (Δ E < 3.5).