Translucency Parameter of Novel Ceramic CAD/CAM Materials

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Outline

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- Objectives
- Materials and Methods
- Results
- Conclusions

Background

Increased demand for esthetic restorations

- Composite resins
- Ceramics
  - Feldspathic porcelain fused to metal substructure
  - Lithium disilicate (Kelly, 2008)
  - Zirconia oxide (Jansen et al, 2019)

Lithium Disilicate

Glass ceramic (Kelly, 2008)

- Randomly organized crystals
  - Deflect crack propagation (Shenoy and Shenoy, 2010)
  - Minimize refraction/reflection
    - Excellent esthetics (Shenoy and Shenoy, 2010)
  - Provide adequate flexural strength
    - As high as 500MPa (IPS e.max, 2019)

Zirconia Oxide

Polycrystalline oxide material

- Exists in three phases, each with distinct properties
  - Monoclinic, tetragonal, and cubic (Sanal and Killinc, 2020)
  - Tetragonal (best properties) stabilized with yttrium oxide (Jansen et al, 2019)
- Excellent mechanical properties
  - 1200 MPa for tetragonal (Jansen et al, 2019)
- Questionable esthetic properties
  - Esthetics can be improved at the expense of mechanical properties (Jansen et al, 2019)

Background

Optical properties

- Color (value, hue, and chroma)
- Translucency
  - Determined by light that is absorbed, transmitted, or reflected (Luo and Rigg, 2001)
- Opalescence
  - Ability to reflect blue wavelength when illuminated with white light (Ardu et al, 2008)

New materials

Tessera (Dentsply Sirona)

- Novel lithium disilicate and lithium aluminum silicate (Virgilite) material
- Reported crystallization time of only 4.5 minutes in the CEREC SpeedFire furnace
- Reported esthetic properties equal to the gold standard, IPS e.max CAD (Ivoclar Vivadent)

New materials

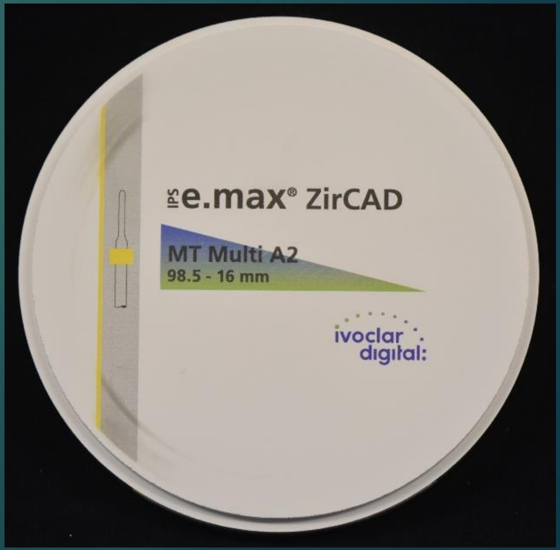
IPS e.max ZirCAD Prime (Ivoclar Vivadent)

- Gradient technology combining 3Y-TZP and 5Y-TZP
- Seamless progression with 3Y-TZP in the dentin zone and 5Y-TZP in the incisal/occlusal zone

New materials

IPS e.max ZirCAD Multi (Ivoclar Vivadent)

- Gradient technology combining 4Y-TZP and 5Y-TZP
- Seamless progression with 4Y-TZP in the dentin zone and 5Y-TZP in the incisal/occlusal zone



New materials

VITA YZ ST

- 4Y-TZP monoblock with reported improved esthetics.

Objective

The purpose of this study was to evaluate the optical properties of these new CAD/CAM materials and compare them to more established all-ceramic materials on the market.

Null Hypotheses

- There is no difference in optical properties between the different CAD/CAM ceramics
- There is no difference in optical properties for CAD/CAM ceramics at various thicknesses

Materials and Methods

3 lithium disilicate groups:

- IPS e.max CAD (control) (Ivoclar Vivadent)
- Tessera regular fire (Dentsply Sirona)
- Tessera Speed Fire (Dentsply Sirona)

Materials and Methods

5 zirconia oxide groups:

- IPS e.max ZirCAD MT (control) (4Y-TZP) (Ivoclar Vivadent)
- Katana STML (4Y-TZP) (Kuraray Noritake)
- VITA YZ ST (4Y-TZP) (VITA)
- IPS e.max ZirCAD MT Multi (4Y-TZP/5Y-TZP) (Ivoclar Vivadent)
- IPS e.max ZirCAD Prime (3Y-TZP/5Y-TZP) (Ivoclar Vivadent)

Materials and Methods

Specimen preparation

- Specimen dimensions:
  - Thickness: 0.5, 1.0, 1.5, or 2.0 mm
- 10 specimens were fabricated for each group (32 groups)

Materials and Methods

Specimen preparation

- Lithium disilicate materials
  - Sectioned blocks using precision saw
  - Crystallized according to manufacturers specifications
- Zirconia oxide materials
  - Milled specimens from zirconia discs
    - The two gradient materials were centered within the transition zone
  - Sintered according to manufacturers specifications

Materials and Methods

Optical property evaluation

- Measured using VITA Easyshade V
  - Color
  - Translucency
  - Opalescence

Optical Property Evaluation

Color

- Measured under standard illuminant (D65)
- Specimens were in direct contact with spectrophotometer aperture
- Each specimen was measured three times

Optical Property Evaluation

Translucency Parameter

- Color was measured against black and white backgrounds
- Calculation:

$$TP_{00} = \sqrt{\left(\frac{L_B - L_W}{k_L s_L}\right)^2 + \left(\frac{C_B - C_W}{k_C s_C}\right)^2 + \left(\frac{H_B - H_W}{k_H s_H}\right)^2 + RT\left(\frac{C_B - C_W}{k_C s_C}\right) * \left(\frac{H_B - H_W}{k_H s_H}\right)}$$

  - k_L, k_C, and k_H corrections for experimental conditions and are set to 1.0 in this study
  - S_L, S_C, S_H are constants that adjust for variation in the L*a*b* coordinate system

Optical Property Evaluation

Opalescence Parameter

- Color was measured against black and white backgrounds
- Calculation:

$$OP = \sqrt{(a_B - a_W)^2 + (b_B - b_W)^2}$$

Data Analysis

Means and standard deviations were calculated for

- Translucency parameter and opalescence parameter
  - Analyzed using two-way ANOVA to evaluate the effects of ceramic type and thickness on translucency and opalescence (alpha=0.05).
  - Analyzed using multiple one-way ANOVAs and Tukey's post hoc tests per material or ceramic thickness (alpha=0.05).

Results

Significant differences were found in translucency and opalescence based on material ($p<0.001$) and thickness ($p<0.001$) with significant interactions ($p>0.05$).

- Each of the materials lost translucency as thickness increased.
- Each of the materials lost opalescence as thickness increased, with the exception of:
  - IPS e.max CAD: had lower opalescence at 0.5mm than 1.0mm
  - IPS e.max ZirCAD MT and Vita YZ ST: had similar opalescence at 0.5mm and 1.0mm.

Results

Significant differences were found in translucency and opalescence based on material ($p<0.001$) and thickness ($p<0.001$) with significant interactions ($p>0.05$).

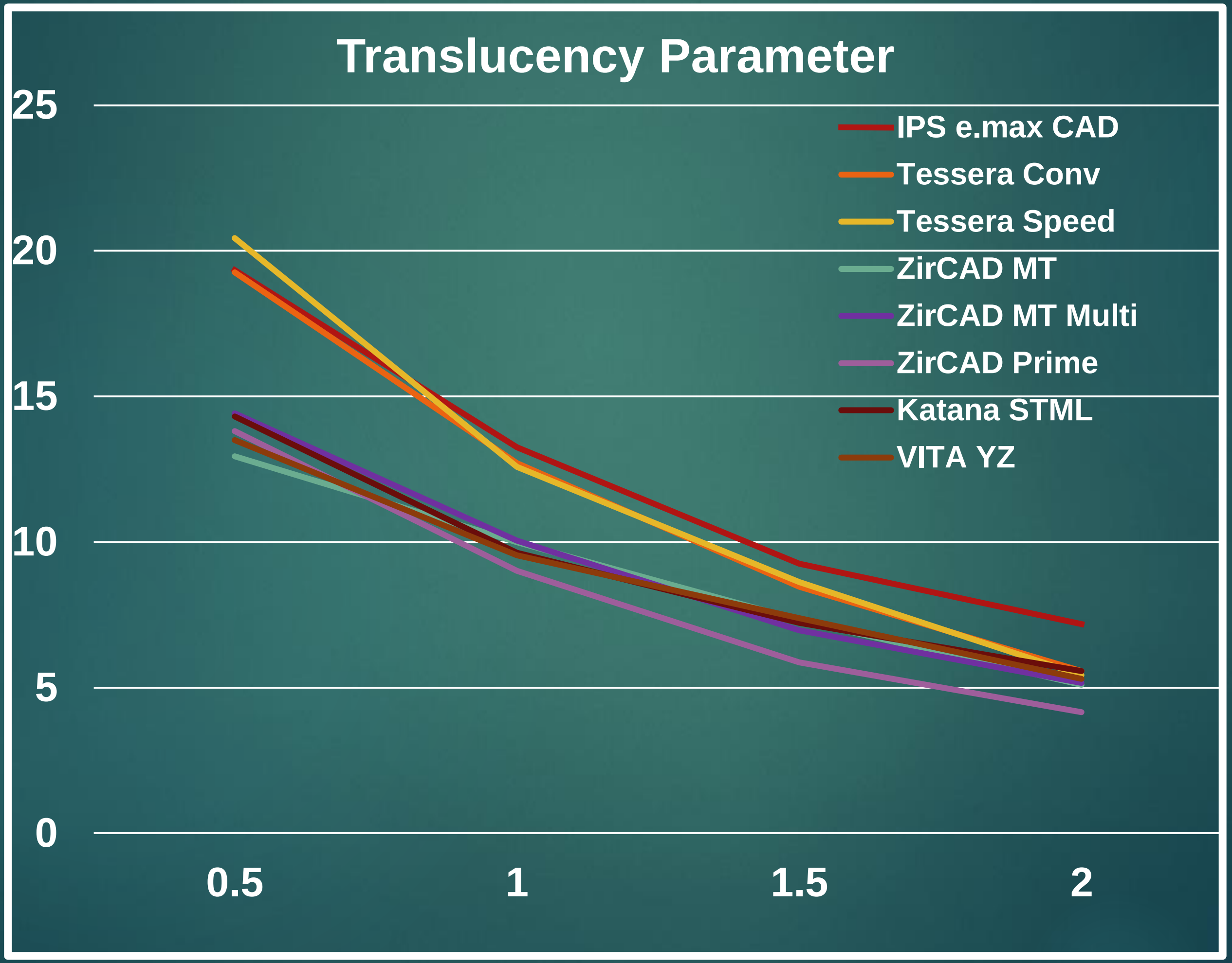
- In general, the glass-ceramic materials had greater translucency and opalescence than the zirconia materials.
- IPS e.max CAD had greater translucency than Tessera at greater thicknesses, and lower opalescence at lesser thicknesses.
- IPS e.max ZirCAD Prime (transition zone) had a tendency to be less translucent than the other zirconia materials at greater thicknesses, and more opalescence at lesser thicknesses.

Results

Translucency parameter

Material	Translucency Parameter 2000 Ceramic Thickness 0.5 mm	1.0 mm	1.5 mm	2.0 mm
IPS e.max CAD	19.34 (0.76) Aa	13.25 (0.51) Ba	9.26 (0.51) Ca	7.18 (0.31) Da
Tessera (Conventional)	19.26 (3.01) Aa	12.71 (0.44) Bb	8.46 (1.12) Cb	5.57 (0.30) Db
Tessera (Speed)	20.44 (0.46) Aa	12.58 (0.73) Bb	8.62 (0.41) Cab	5.43 (0.46) Dbc
IPS e.max ZirCAD MT	12.94 (0.11) Ab	9.99 (0.15) Bc	7.32 (0.07) Cc	5.10 (0.06) Dc
IPS e.max ZirCAD MT Multi	14.42 (0.13) Ab	10.05 (0.09) Bc	6.97 (0.23) Cc	5.16 (0.10) Dc
IPS e.max ZirCAD Prime	13.81 (0.35) Ab	9.01 (0.13) Bd	5.87 (0.11) Cd	4.16 (0.10) Dd
Katana STML	14.31 (0.13) Ab	9.63 (0.19) Bc	7.22 (0.18) Cc	5.57 (0.08) Db
VITA YZ ST	13.50 (0.27) Ab	9.54 (0.18) Bc	7.38 (0.13) Cc	5.30 (0.20) Dbc
Groups with the same upper case letter per row or lower case letter per column are not significantly different (p>0.05).				

Results



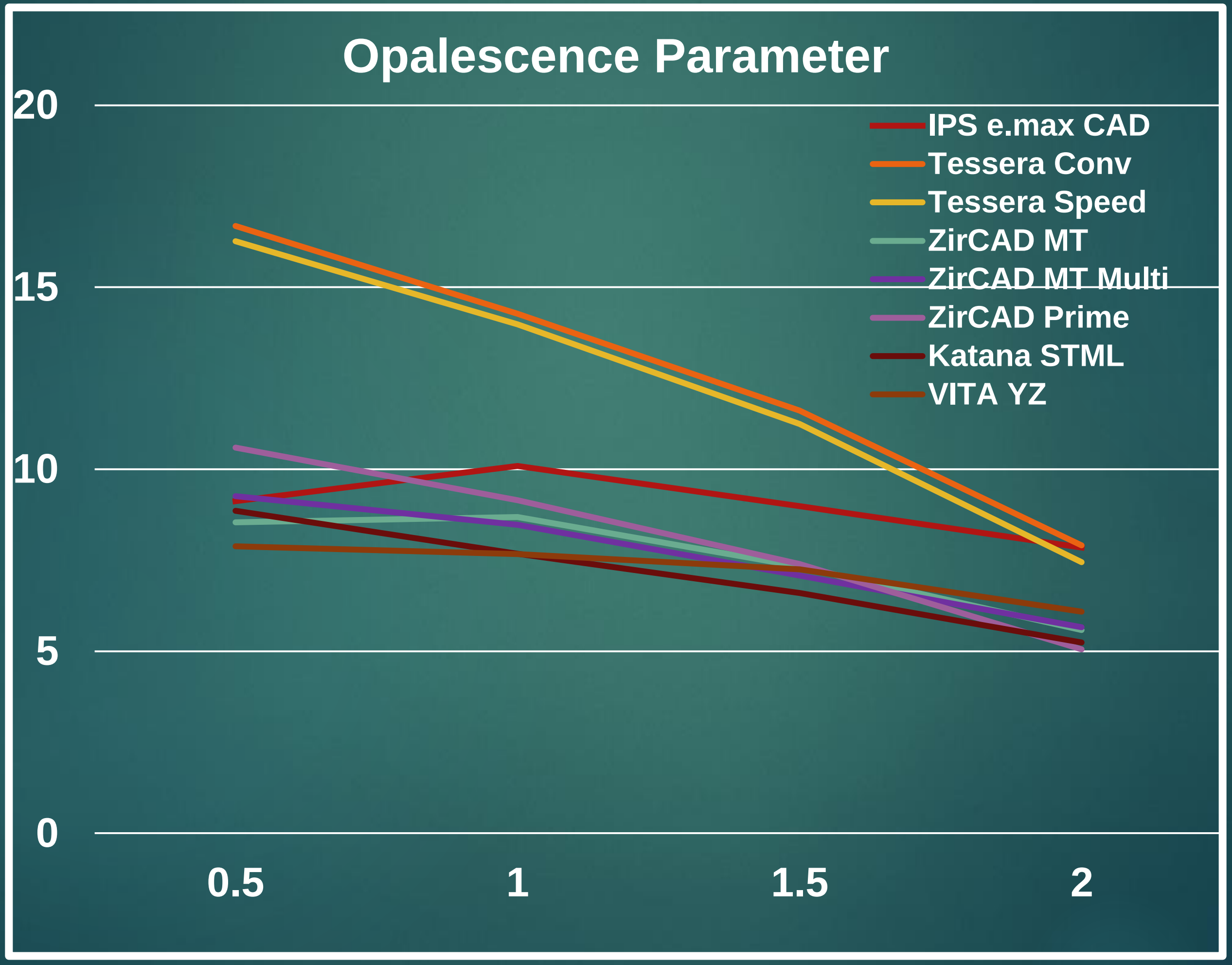
Translucency Parameter
25
20
15
10
5
0
0.5
1
1.5
2
IPS e.max CAD
Tessera Conv
Tessera Speed
ZirCAD MT
ZirCAD MT Multi
ZirCAD Prime
Katana STML
VITA YZ

Results

Opalescence parameter

Material	Opalescence Parameter Ceramic Thickness			
	0.5 mm	1.0 mm	1.5 mm	2.0 mm
IPS e.max CAD	9.12 (0.19) Bde	10.09 (0.19) Ac	8.99 (0.34) Bb	7.85 (0.31) Ca
Tessera (Conventional)	16.68 (0.54) Aa	14.27 (0.54) Ba	11.61 (2.66) Ca	7.91 (0.52) Da
Tessera (Speed)	16.26 (0.36) Ab	13.98 (0.89) Bb	11.24 (0.53) Ca	7.45 (1.11) Da
IPS e.max ZirCAD MT	8.54 (0.09) Af	8.69 (0.16) Ade	7.33 (0.11) Bc	5.58 (0.20) Cbc
IPS e.max ZirCAD MT Multi	9.26 (0.32) Ad	8.47 (0.17) Be	7.08 (0.14) Cc	5.66 (0.11) Dbc
IPS e.max ZirCAD Prime	10.59 (0.02) Ac	9.15 (0.17) Bd	7.40 (0.20) Cc	5.05 (0.17) Dc
Katana STML	8.86 (0.10) Aef	7.68 (0.09) Bf	6.60 (0.21) Cc	5.24 (0.09) Dc
VITA YZ ST	7.88 (0.12) Ag	7.67 (0.18) Af	7.25 (0.26) Bc	6.09 (0.29) Cb
Groups with the same upper case letter per row or lower case letter per column are not significantly different ($p>0.05$).				

Results



Opalescence Parameter
20
15
10
5
0
0.5
1
1.5
2
IPS e.max CAD
Tessera Conv
Tessera Speed
ZirCAD MT
ZirCAD MT Multi
ZirCAD Prime
Katana STML
VITA YZ

Conclusions

Differences in translucency and opalescence parameters varied based on the type of ceramic material and thickness.

Questions?