Flexural Fatigue Behavior of New All-Ceramic CAD/CAM Materials

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23 Mar 2022

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Outline

- Background
- Objectives
- Materials and Methods
- Results
- Conclusion

Background

- Increased demand for efficiency, productivity, and naturalistic esthetics
  - Ceramics
    - Lithium disilicate
    - Zirconia oxide

Lithium Disilicate

- Glass ceramic (Kelly, 2008)
  - Randomly organized crystals
    - Deflect crack propagation (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 an be improved at the expense of mechanical properties (Jansen et al, 2019)

New materials

- Tessera
  - New novel lithium dislicate and lithium aluminum silicate (Virgilite) material
  - Reported material has a crystallization time of only 4.5 minutes in the CEREC SpeedFire
  - Reported biaxial flexural strength greater than 700 MPa in a 1.0mm preparation design

New materials

- IPS e.max ZirCAD Prime and MT Multi
  - Gradient technology is a unique manufacturing process that uses special powder conditioning to combine 3Y-TZP and 5Y-TZP or 4Y-TZP and 5Y-TZP
  - Seamless progression of strength with 3Y-TZP or 4Y-TZP in the dentin zone and 5Y-TZP in the incisal or occlusal translucent zone

Objective

- The purpose of this study was to compare the flexural fatigue behavior of new chairside and lab CAD/CAM materials to established materials on the market.

Null Hypotheses

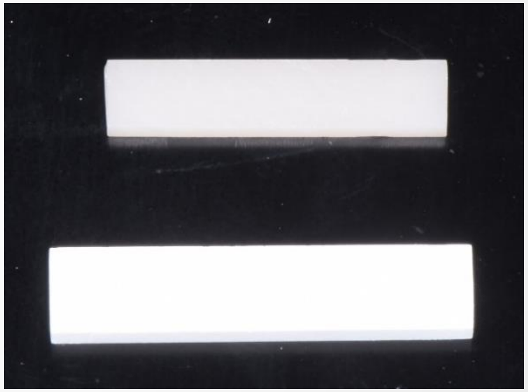
- There will be no difference in in flexural strength, flexural fatigue behavior, and endurance between the different ceramic materials.

Materials and Methods

- Materials
  - 2 lithium disilicates
    - IPS e.max CAD (control) (Ivoclar Vivadent)
    - Tessera (Dentsply)
  - 4 zirconia oxides
    - IPS e.max ZirCAD MT (control) (4Y-TZP) (Ivoclar Vivadent)
    - Katana STML (4Y-TZP) (Kuraray Noritake)
    - IPS e.max ZirCAD MT Multi (4Y-TZP/5Y-TZP) (Ivoclar Vivadent)
    - IPS e.max ZirCAD Prime (3Y-TZP/5Y-TZP) (Ivoclar Vivadent)
    - VITA YZ ST (4Y-TZP) (VITA Zahnfabrik)

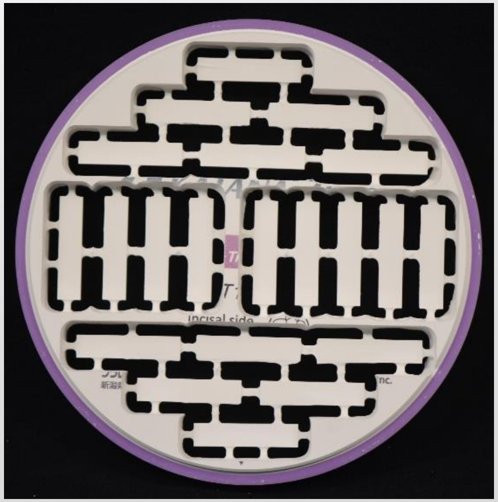
Materials and Methods

- Specimen preparation
  - Specimen dimensions:
    - Length and width: 18.0 mm x 4.0 mm
    - Thickness: 1.3 mm
  - 30 specimens were fabricated for each group(7)
    - 90 specimens for Tessera
      - 30 no glaze regular fire
      - 30 glazed regular fire
      - 30 glazed speed fire



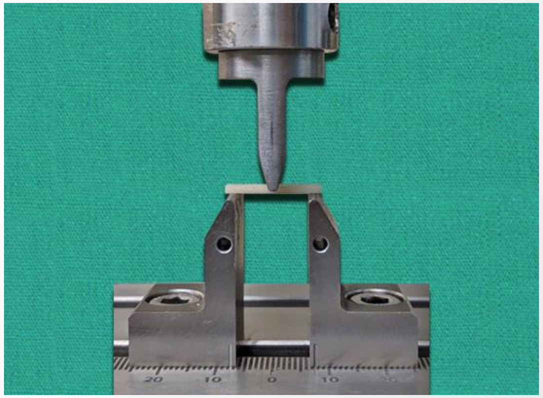
Materials and Methods

- Specimen preparation
  - Lithium disilicate materials
    - Milled from blocks in a IsoMet 5000, (linear precision saw, Buehler)
    - Crystallized according to manufacturers specifications
  - Zirconia oxide materials
    - Specimens were milled from zirconia discs
      - The two gradient materials was centered within the gradient
    - Sintered according to manufacturers specifications



Materials and Methods

- Flexural Strength
  - Fifteen beam specimens per group
    - Fractured in universal machine
    - 3-point bending-test device
  - Central load were applied with a head diameter of 2.0mm
  - Flexural strength calculation
    - FS = $3Fl/2bd^2$



Flexural Fatigue Strength

- Staircase method
  - Fifteen beams per group
  - 3-point test device
  - Load profile was determined based on the single load to fracture data
  - 100,000 cycles until specimen failure or survival at 20 Hz
  - 20% increase/decrease of initial starting force value
    - Based on survival or failure

$$\sigma_{ff} = X_0 + d\left(\frac{\sum in_i}{\sum n_i} \pm 0.5\right)$$

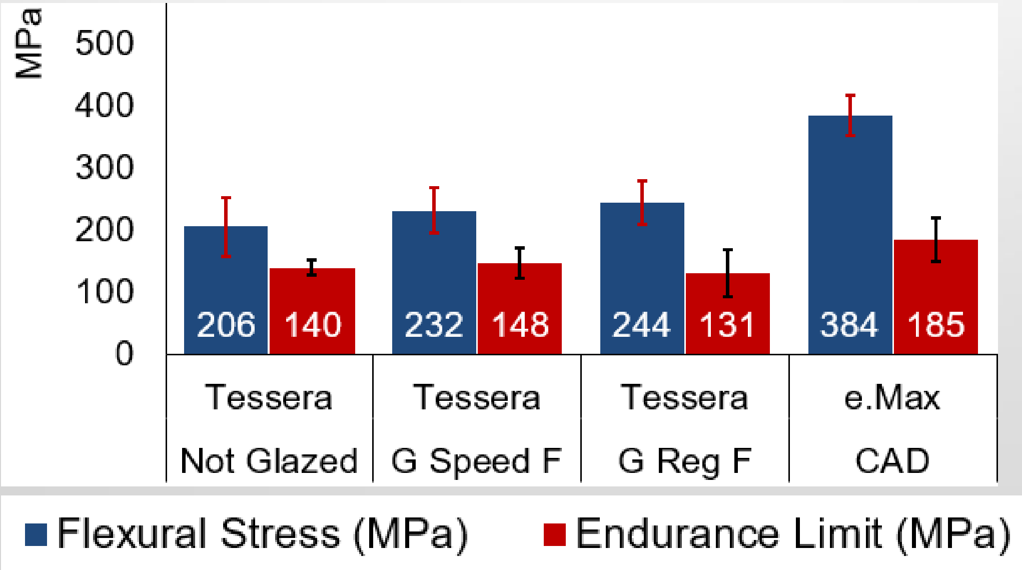
$$\mathrm{SD} = 1.62d\left(\frac{\sum n_i \sum i^2 n_i - \left(\sum in_i\right)^2}{\left(\sum n_i\right)^2} + 0.029\right)$$

Data Analysis

- Means and standard deviation for flexural strength was calculated for each ceramic material
  - Kaplan-Meier survival test
    - Analyzed using one-way ANOVA and Tukey's post hoc tests to (alpha=0.05)
- Weibull Modulus

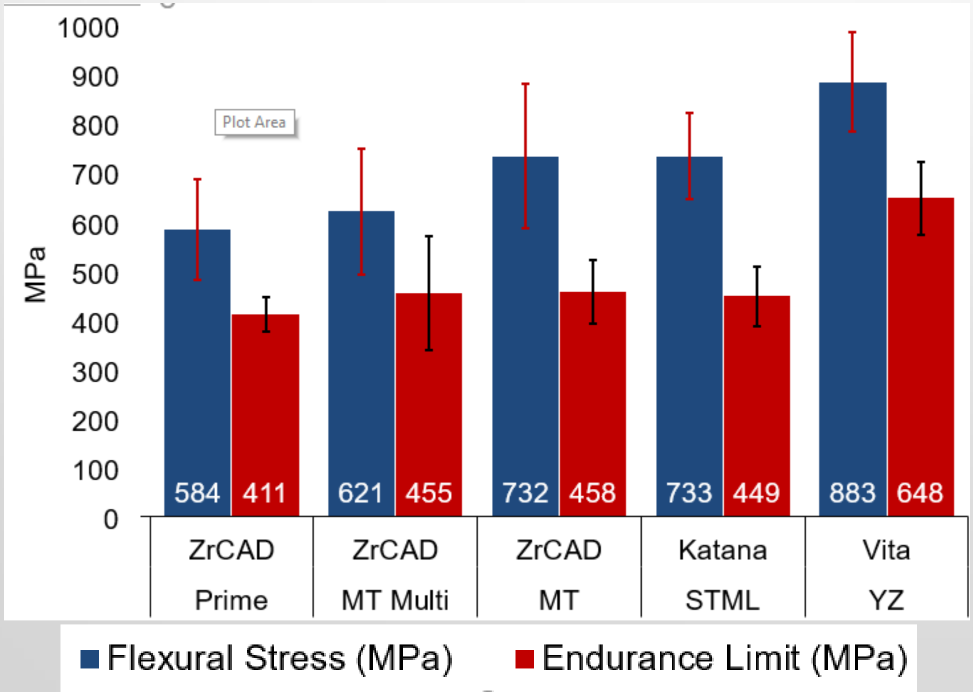
Results

- Significant differences between groups
  - Silica based
    - IPS emax CAD vs Tessera
      - Flexural strength of e.max 384.14 compared to 206.07-243.61 for Tessera
      - No significant differences in flexural fatigue limits



Results

- Significant differences between groups
  - Oxide-based ceramics
    - Vita YZ had the greatest flexural strength and fatigue



Conclusion

- Oxide-based, zirconia exhibited higher values for all properties evaluated when compared to silica-based ceramics
- Tessera vs IPS e.max CAD
  - Tessera has significantly flexural stress value
  - Tessera is comparable to IPS e.max CAD is fatigue behavior and endurance limits

Questions?