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Research Article

Effect of Thermocycling on Flexural Strength of Different CAD/CAM Material

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Abstract

Purpose of Study: To investigate the impact of thermocyclic on the flexural strength of chairside CAD/CAM restorative materials.

Method: six materials were selected to evaluate the flexural strength after thermalcycling, These materials are Telio CAD, VITA CAD-Temp, 3M™ ESPE™ Lava™ Ultimate Restorative and CERASMART, lithium disilicate ceramic (e-max CAD) and composite resin (Paradigm MZ100). Twenty rectangular specimens were prepared with the dimension of 14 mm × 4 mm × 2 mm for each material and divided into two groups of 10 specimens each. First group for each material was thermo-cycled between water temperature of 5 and 55°C for 5,000 cycles. The second group were subjected to three-point bending test on a 10mm span, using Instron universal mechanical tester (5566A) at a crosshead speed of 0.5 mm/min. Statistical analysis was performed using ANOVA Tukey test and modeling least square means difference regression with JMP11.

Results: The mean flexural strength of the materials tested ranged from 380 ± 20 MPa to 108 ±4 MPa. The mean flexural strength after thermocycling of the materials tested ranges from, 313 ± 56 MPa to 94 ± 4 MPa respectively.

Conclusion: There was Significant differences in the mean of flexural strength of the tested materials were observed. Within the limitation of the study, the thermocycling treatment has no significant difference impact on the flexural strength compared to water soaking. (p =0.11)

Keywords: Flexural strength; Thermocycling; Restorative materials

Introduction

A number of chairside CAD/CAM restorative materials demonstrate predictability and longevity. These materials include esthetic ceramics that contain a glassy phase, allowing restorations to be etched and bonded to the tooth. Feldspathic (Vitabloc Mark II) and Leucite reinforced (IPS Empress CAD) are examples of such ceramics. High- strength ceramics, such as IPS e.max CAD, offer an increase in flexural strength compared to esthetic ceramics [1,2].

Two types of composite resin blocks commercially available include Paradigm MZ100 that is recommended for final restorations, and Vita CAD Temp and Telio CAD used primarily in long-term temporization. Hybrid Nanocomposite is a unique dental material combining the best characteristics of a high strength ceramic and a composite [3]. In addition to its high degree of flexibility, glossy surface finish, strength, and breaking energy, this material helps to ensure better edge quality and smooth margins. As a result, this material is ideally suited for inlays, onlays, veneers, and crowns. Lava™ Ultimate Restorative and CERASMART are two examples of hybrid nanocomposites [3]. A diverse variety of CAD/CAM materials function in multiple clinical applications, making CAD/CAM technology so vital to dentistry.

Chairside CAD/CAM materials are widely adapted in prosthodontics because of their advantageous properties including esthetic, biocompatible, and inert. Among many reported shortcomings, brittle ceramics are susceptible to flaws and defects, which may develop as a result of thermal, chemical, or mechanical processing. Therefore, these restorations are prone to complete failure when subjected to tensile stress. Efforts to enhance the service life of all-ceramic materials focus on improving their strength (σ) and fracture toughness [1].

Strength of dental materials is one of the most important mechanical properties that determine clinical performance and survival rate of dental restorations. The strength of a material can be defined by the maximum or critical stress that a material can withstand before fracture [4-7]. Flexural strength is the ability of the material to bend before breakage. Flexural strength is the highest stress experienced within the material at rupture and is measured in terms of stress, here given the symbol σ.

In 2005 J. De Munck and his colleagues reported that the ISO TR 11450 standard (1994) suggests that a thermo-cycling regime composed of 500 cycles in water between 5 and 55°C is an appropriate artificial aging test [8].

Gale and Darvell et al., 1999 concluded that 10,000 cycles are equivalent to approximately 1 year of *in vivo* function, thus studying only 500 cycles, as proposed by the ISO standard, is a minimal approach to assay long-term bonding effectiveness. Artificial aging can progress during thermo-cycling in two ways: (1) Hot water may accelerate hydrolysis of interface components and cause extraction

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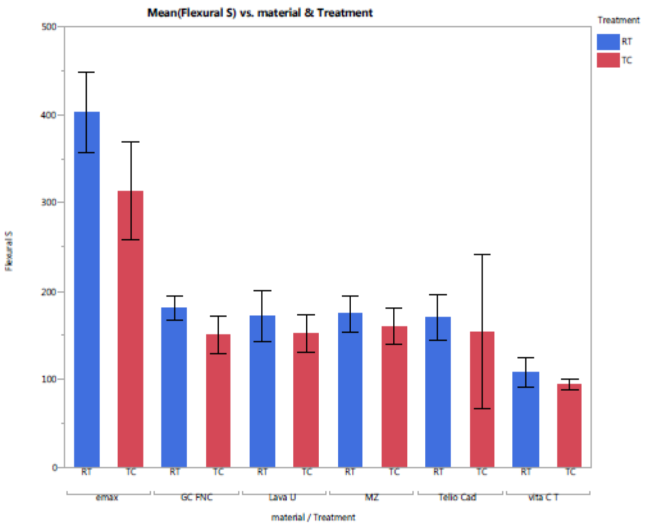

Figure 1: Means of flexural strength of materials with different treatment (Regular Treatment (RT) and after Thermal Cycling (TC).

of breakdown products or poorly polymerized resin oligomers (Miyazaki et al., 1998) or (2) A higher thermal contraction/expansion coefficient in the restorative materials at the interface with normal teeth may result in resin breakdown [4,9].

Purpose of this study was to investigate the effect of thermo-cycling on the flexural strength of the chairside CAD/CAM materials.

Materials and Methods

Materials

Six different CAD/CAM materials were used in this in-vitro study.

Vita CAD temp: The Vita CAD Temp composite block is a cross-linked acrylate polymer with microfiller manufactured by (VITA Zahnfabrik, Bad Säckingen, Germany) [10].

Paradigm MZ100: Paradigm MZ100 block material consists 85% by weight of ultrafine zirconia- silica ceramic particles and reinforced by high cross-linked polymeric matrix (bisGMA (Bisphenol A diglycidyl ether dimethacrylate) and TEGDMA (tri ethylene glycol dimethacrylate) manufactured by 3M ESPE, USA [11].

Telio CAD: Telio CAD is an acrylate polymer (PMMA) block manufactured by Ivoclar Vivadent Schaan, Liechtenstein [12].

IPS e.max CAD: IPS e.max is a lithium disilicate glass-ceramic block manufactured by Ivoclar Vivadent, Schaan, Liechtenstein.

Lava Ultimate Restorative: Ultimate Restorative is a Nano composite resin that is comprised of Filler by weight of approximately 80% (20 nm silica particles; 4–11 nm zirconia particles and 0.6–10 nanoparticle clusters) and reinforced by Matrix (Bis-GMA, Bis-EMA, UDMA, TEGDMA). That is manufactured by 3M ESPE, USA [13].

CERASMART: CERASMART is a CAD/CAM block that is comprised of a flexible and evenly distributed nano ceramic matrix that is manufactured by GC America.

Methods

Flexural strength (static): A total of ten rectangular specimens of each material were prepared with dimension of 14 mm×4 mm×2 mm using a 15LC diamond-wafering blade mounted on an Isomet 2000 Precision Saw (Buehler, Lake Bluff, Illinois). The cuts were made at 800 rpm with 300 grams of load with cooling provided by a dual-nozzle water irrigation system. Specimen dimensions were verified after sectioning using micrometer (model no. 293-715 Japan).

The specimen was polished using a Buehler EcoMet 250 Grinder-Polisher (Buehler, Lake Bluff, Illinois). The polishing protocol is as follows: Burrs are removed on a 15-micro-grit diamond polishing pad at 250 rpm with water irrigation then both sides of the specimen are run on a 15-mirco-grit diamond polishing pad at 250 rpm with water irrigation for 90 seconds for each side, and then thoroughly rinsed. The two sides of the specimen are then run on the Texmet polishing pad (Buehler, Lake Bluff, Illinois) with 6- micron polycrystalline diamond at 200 rpm for 120 seconds for each side, and then rinsed. Lastly, both sides of the specimen are run on a Mastertex polishing pad (Buehler, Lake Bluff, Illinois) with 1-micron polycrystalline diamond at 150 rpm for 120 second, and then rinsed.

The specimens were aired dry for 24 hours before testing begins. A three-point flexural test was conducted on the specimen using Instron 5566A Universal Testing Frame (Instron, Norwood, Massachusetts) with 1k N load cell.

Ten specimens from each material were positioned on the fixture and centered under the loading apparatus with perpendicular alignments and subjected to three-point bending test on a 10mm span, using Instron universal mechanical tester 5566A at a crosshead speed of 0.5mm/min. Each specimen is loaded with the force until the failure of the specimen occurs. The controlling software calculates the maximum load and maximum extension. Fractured pieces of the specimen are recovered and stored in a sealed sleeve for futures uses. The data collected by a bending test, combined with the post failure specimen measurements, permit the calculation of the values of Flexural Strength [MPa] and Modulus of Elasticity [MPa] for all specimens according to the formula of flexural strength and modulus of elasticity as shown below:

$\boldsymbol{\sigma = 3Pl/2wh^2}$

Where σ =Flexural Strength (MPa)

P is the Breaking load (N)

1 is the Test span (mm)

w is the Width of the specimen (mm)

h is the Thickness of the specimen (mm)

$\boldsymbol{\sigma = . E \varepsilon}$

Where σ is Stress [MPa]

E = Modulus of elasticity [MPa] and ε Strain [unitless or %]

The results are reported as mean and standard deviations for all materials tested and statistical significance of the values were analyzed using One-Way Analysis of Variance (ANOVA).

Thermal cyclic: A total of ten rectangular specimens for each material were prepared and polished as mentioned previously. All the samples were subjected to the same temperature changes for the same

Table 1: Means of flexural strength of materials after thermal cycling.

		Flexural S	
Material	Treatment	Mean	Std Dev
IPS emax	RT	402.33	45.8
	TC	313.71	56.05
CERASMART	RT	181.15	13.56
	TC	150.44	21.42
Lava U R	RT	171.78	29.24
	TC	152.06	21.2
MZ 100	RT	174.39	20.42
	TC	160.4	20.97
Telio Cad	RT	169.95	25.83
	TC	154.35	87.55
Vita CAD T	RT	108.33	16.52
	TC	94.08	6.47

time period by repetitive immersion into cold 5°C and subsequently hot 55°C water baths for 5000 cycles.

Thermal cyclic apparatus: The thermal cyclic apparatus consists of two tanks holding hot and cold water. Tap water was used to fill both tanks in order to mimic the oral cavity environment that is frequently exposed to tap water. The hot water incubator was set and maintained at 55°C by a thermostat. The temperature of the cold water was set at 5°C. A basket containing specimens was moved between the two tanks at pre-selected times. A counter recorded the number of cycles during testing. For this experiment, the samples were placed 30 seconds in the hot bath and then 30 seconds in the cold bath for one cycle and the process repeated for 5000 cycles. Movement of the samples between the hot and cold tanks took 20 seconds. The thermal cyclic specimens were subsequently subjected to the three-point bending test.

Results

The flexural strength was measured using a 3-point bending test. (Table 1) shows the mean flexural strength ± standard deviation [MPa] for each of six materials tested after subjecting to thermal cycling (5-55°C).

The mean flexural strength (FS) of the materials tested after thermal cycling ranges from 313 ± 56 MPa for IPS e.max CAD, to 150 ± 21 MPa for CERASMART, to 152 ± 21 MPa for Lava Ultimate Restorative. Paradigm MZ10 has a mean flexural strength of 160 ± 20 MPa, followed by Telio CAD 154 ± 87 MPa and Vita CAD Temp 94 ± 6 MPa respectively (Figure 1).

One-way ANOVA and post HOC Tukey HSD tests were used for statistical analysis of the flexural strength data. The ANOVA test reveals that TC treatment has no significant impact on FS compared to water soaking (p=0.11). E.max and Vita C T show significantly higher FS than other materials (p <0.001 for both). E.max and CERASMART have significantly lower FS after TC treatment (p=0.0015 for both), whereas Lava U and MZ100 show no significant change in FS after TC treatment (p=0.0572 and p=0.1481 respectively). Telio CAD and Vita CAD show no significant change in FS after TC treatment (p=0.5974 and p=0.205 respectively).

Discussion

In this study we compared the flexural strength of six different chairside CAD/CAM restorative materials. To interpret our experimental observations we compare our findings with publications and data available from manufacturers about the restorative materials. Telio CAD and Vita CAD Temp are provisional materials first available commercially approximately five years ago.

These materials are the subject of numerous research studies and quality primary articles in the literature. Lava Ultimate R is a relatively new material that became commercially available in the last two years. There are only five publications in the literature relevant to Lava Ultimate R, thus more research is required to fully understand this material. Regarding CERASMART, there are currently no publications related to this material that only became commercially available within the last year. Thus, a comparison of our findings with the literature is not possible for CERASMART. There are abundant publications focusing on the properties of MZ100 and IPS emax CAD.

Vita CAD temp

The flexural strength for Vita CAD Temp observed in this study of 108 MPa is similar to published findings and manufacturer's data of 80 MPa. The flexural strength observed after thermal cycling at 94 MPa for 5000 cycles is comparable to published data [10].

CERASMART

This material is not completely characterized because CERASMART has only been commercially available for less than one year. In this study, the flexural strength for CERASMART of 182 MPa is less than the manufacturer's published data of 238 MPa. Due to the paucity of published studies to compare this result to, the reason for this discrepancy is not clear. Flexural strength after thermal cycling for 5000 cycles is 150 MPa, which is comparable to the manufacturer's published data of 163 MPa after 10000 cycles.

Lava ultimate restorative

The flexural strength observed for Lava U in this study at 171 MPa differs from the manufacturer's published data and results found in the literature of 204 MPa. Flexural strength after thermal cycling for 5000 cycles was 154 MPa, which is higher than previously published results of 100 MPa.

Paradigm MZ100

The flexural strength obtained for MZ100 in this study of 174 MPa is comparable to manufacturer's published data and reports in the literature of 170 MPa. The flexural strength obtained after thermal cycling of 160 MPa for 5000 cycles is comparable to the manufacturer's published data and reports in the literature at 150 MPa.

IPS e.max CAD

In this study the flexural strength of 400 MPa for IPS emax CAD is comparable to manufacturer's published data and findings in the literature of 360 MPa. A flexural strength of 313 MPa after thermal cycling for 5000 cycles is comparable to the manufacturer's published data and the literature at 320 MPa.

Telio CAD

The flexural strength for Telio CAD in this study of 169 MPa is higher than the manufacturer's data and published results of 130

MPa. The flexural strength of 154 MPa after thermal cycling for 5000 cycles is higher than the manufacturer's report and published observations of 120 MPa.

The main limitations of this study are expressed as follows: the first limitation concerns the design and methodology that impacted the interpretation of the findings from the research. Second limitation is the lack of the materials that were used and aged thermocyclic machine. Lastly, to improve the study in the future, new sophisticated thermocyclic machine should be used; other CAD/CAM blocks can be tested.

Conclusion

Within the limitations of this *in vitro* study the following conclusions can be drawn:

- Significant differences in the mean of flexural strength of the tested materials were observed.
- Thermocycling treatment has no significant difference impact on the flexural strength compared to water soaking.

References

1. American Dental Association. Revision of the ANSI/ADA specification No.15 for synthetic resin teeth. Chicago: American Dental Association. 1998: 1-11.
2. Giordano R. Materials for chairside CAD/CAM-produced restorations. J Am Dent Assoc. 2006; 137: 14S-21S.
3. Curtis AR, Palin WM, Fleming GJ, Shortall AC, Marquis PM. The mechanical properties of nanofilled resin-based composites: The impact of dry and wet cyclic pre-loading on bi-axial flexure strength. Dent Mater. 2009; 25: 188-197.
4. Nalla RK, Kinney JH, Marshall SJ, Ritchie RO. On the *in vitro* Fatigue Behavior of Human Dentin: Effect of Mean Stress. J Dent Res. 2004; 83: 211-215.
5. Beuer F, Schweiger J, Edelhoff D. Digital dentistry: an overview of recent developments for CAD/CAM generated restorations. Br Dent J. 2008; 204: 505-511.
6. J.L. Drummond. Degradation, Fatigue, and Failure of Resin Dental Composite Materials. J dent res. 2008l; 87: 710- 719.
7. Chen HY, Hickel R, Setcos JC, Kunzelmann KH. Effects of surface finish and fatigue testing on the fracture strength of CAD-CAM and pressed-ceramic crowns. The Journal of prosthetic Dentistry 1999; 82: 468-475.
8. De Munck, J, Van Meerbeek B, Wevers M, Lambrechts P, Braem M. Micro-rotary fatigue of tooth-biomaterial interfaces. Biomaterials. 2005; 26: 1145–1153.
9. Gale MS, Darvell BW. Thermal cycling procedures for laboratory testing of dental restorations. J Dent.1999; 27: 89-99.
10. Vita CAD temp Technical Product Profile. VITA Zahnfabrik; 2010.
11. 3M Paradigm MZ100 Block Technical Product Profile. 3MDental Products; 2000.
12. Telio CAD Block Technical Product Profile. Ivoclar Vivadent; 2010.
13. Lava Ultimate CAD/CAM Restorative Technical Product Profile. St. Paul, Minnesota: 3M ESPE; 2011.

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