doi: 10.14295/bds.2012.v15i4.839

Effect of thermal treatment on the bending strength of glass ceramic/resin cement

Efeito do tratamento térmico na resistência à flexão do conjunto cerâmica vítrea/cimento resinoso

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Abstract

Objectives: To investigate the effect of the thermal treatment on the bending strength of ceramic bars (VM7) treated by the cementation protocol. Material and Methods: Forty ceramic bars (20 x 4 x 1.2 mm) were constructed and randomly distributed into 2 groups (n=20): NT - without treatment/ control and T – with treatment (50°C above the glass transition temperature, for 15 min). All specimens underwent the cementation process in which one surface of the ceramic bar was etched (20 s) with 10% hydrofluoridric acid, followed by air-water jet washing (60 s), drying (30 s), silane agent application and resin cementation. After storage (distilled water/seven days at 37 ºC), the specimens were submitted to 3-point flexure test at 100% humidity/37 ºC (v=1 mm/min, load cell of 10 kgf). Results: The bending strength values and standard deviations (MPa) were: NT: 19.98 (3.17)a; T: 20.45 (4.67)a (one-way ANOVA and Tukey test, σ=0.05). Conclusions: The thermal treatment did not influence on the bending strength mean values of the ceramics studied.

Keywords

Ceramics; Bending strength; Thermal treatment.

Resumo

Objetivos: Investigar o efeito do tratamento térmico, na resistência à flexão, de barras cerâmicas (VM7) tratadas pelo protocolo de cimentação. Material e Métodos: Foram confeccionadas 40 barras cerâmicas (20 x 4 x 1.2 mm) e distribuídas randomicamente em 2 grupos (n=20): NT - sem tratamento/controle e T - com tratamento (50°C acima da temperatura de transição de fases, durante 15 min). Todos os espécimes receberam o processo de cimentação onde uma face da barra cerâmica foi condicionada (20 s) com ácido fluorídrico 10%, seguida pela lavagem jato ar-água (60 s), secagem (30 s), aplicação do silano e cimentação resinosa. Após armazenagem (água destilada/sete dias à 37 ºC), as amostras foram submetidas ao ensaio de flexão 3 pontos em 100% umidade à 37 ºC (v=1 mm/min, célula de carga de 10 kgf). Resultados: Os valores de resistência à flexão e os desvios-padrão (MPa) para os grupos foram: NT: 19.98 (3.17)a; T: 20.45 (4.67)a (ANOVA one--way e Teste de Tukey, σ=0.05). Conclusões: Verificou-se que o fator tratamento térmico não influenciou nos valores médios de resistência à flexão da cerâmica estudada.

Unitermos

Cerâmicas; Resistência à flexão; Tratamento térmico.

Introduction

Dental ceramics show as main advantages the friable behavior and the low fracture strength [1]. Notwithstanding, because they exhibit desirable properties as excellent aesthetic quality, high hardness and compressive strength, good chemical durability and biocompatibility, a great effort has been made so that its deficiency be overcome.

It has been suggested that one of the failure causes of the ceramic restorations is related to the evolution of the microscopic defects formed during the manufacturing process and restorations adjustments [2].

One alternative that has been suggested to increase the ceramic resistance is the thermal treatment (annealing). It allows a relief of the tension induced to the material during its manufacturing process without altering its characteristics [3].

However, there is a lack of information on the effect of the thermal treatment on the resistance of dental ceramics. Considering the hypotheses that the thermal treatment would or would not exhibit statistical differences, the aim of this study was to investigate its effect on the bending strength of double-layer bars of ceramic/resin cement.

Materials and Methods

The materials used in this study are exposed in Table 1.

Table 1 - Material, Brand name, Manufacturer and Batch

Material	Brand name	Manufacturer	Batch
Ceramic	VITA VM®7	VITA Zahnfabrik, Bad Säckingen, Germany	11040
10% Hydrofluoric Acid	Condicionador de Porcelanas	Dentsply,Petrópolis, RJ, Brazil	21730
Silane	Porcelain Primer	Bisco, Schaumburg, IL, USA	06052
Dual Resin Cement	3M RelyX™ ARC	3M-ESPE, St Paul, MN, USA	459966

Preparation of the ceramic specimens:

With the aid of a metallic matrix (24 x 4.8 x 1.45 mm), forty ceramic bars (20 x 4 x 1.2 mm) were constructed. According to the manufacturer's instructions (VM7, VITA Zahnfabrik, Bad Säckingen, Germany) the powder/liquid ratio was mixed and inserted gradually into the matrix, with the aid of a plaster vibrator. The excess of liquid was removed of the aid of absorbent papers. Next, the bars were fired onto a refractory base in a Vacumat oven (VITA Zahnfabrik, Bad Säckingen, Germany), according to the sintering cycle recommended by the manufacturer (Table 2).

Table 2 - Sintering cycle of the VM7 ceramics

Steps	VM7
Drying time 1 (min)	2
Drying time 2 (min)	3
Vacuum (mmHg)	29
Initial temperature (°C)	500
Maximum temperature (°C)	910
Shutdown temperature vacuum (°C)	910
Heating rate (°C/min)	55
Cooling time 1 (min)	3
Cooling time 2 (min)	3
Cooling time 3 (min)	0

Then, the internal structure of each ceramic bar was radiographically assessed to observe possible failures. If present, the specimens were excluded from the study.

All specimens were submitted to finishing procedure with the aid of 1200-grit sandpapes [4] followed by sonic cleaning (Vitasonic, VITA Zahnfabrik, Bad Säckingen, Germany) with deionized water for 5 minutes.

Following, the ceramic bars were randomly distributed into 2 groups (n=20): NT - without thermal treatment /control and T - with thermal treatment.

The thermal treatment (annealing) consisted of increasing the oven temperature at 50°C above the glass transition temperature (tg) of the ceramics (550°C-600 °C) for 15 minutes [3].

Next, the ceramic bars were etched (60 s) with 10% hydrofluoric acid (Dentsply, Petrópolis, RJ, Brazil). The bars were washed with air-deionized water jet for 60 seconds, immersed in sodium bicarbonate solution, submitted to ultrasound and air jet drying for 30 seconds.

The amount of neutralization time into supersaturated bicarbonate solution was twice the etching time with hydrofluoridric acid (120 s) and the time of ultrasound bath was 4 minutes.

Following, a silane bonding agent (Porcelain Primer, Bisco, Schaumburg, IL, USA) was applied

according to the manufacturer's instructions. The dual resin cement (RelyX ARC, 3M-ESPE, St Paul, MN, USA) was applied onto the bar and protected with a polyester strip and glass lamina. The set (ceramic bar/cement/polyester strip/glass lamina) was positioned into a press with load of 750 g perpendicular to the cementation surface, generating a uniform cement pellicle. Prior to the light-curing (40 s) (UltraLED, Ultradent Products Inc, South Jordan, UT, USA), with light intensity of 400 mW/cm2, the excesses were removed with a brush. Then, the specimens were stored into distilled water at 37°C for one week.

Mechanical test:

Initially, an adhesive tape was placed onto the bar surface receiving the load (opposed to the cementation), to prevent the completely separation after the catastrophic failure. Following, each bar was placed into a metallic device (supported onto two cylinders of 2 mm of diameter, with distance between centers of 16 mm). Only the extremities of the specimens were used for supporting, so that their central part was free to receive the load. This was applied onto the surface opposed to the cementation, through a rod with a cylindrical active tip (2 mm of diameter) coupled to a universal testing machine (EMIC DL 1000, São José dos Pinhais, PR, Brazil), and submitted to compression (v=1 mm/min, load cell of 10 kgf) up to the catastrophic failure [4]. All mechanical test occurred at 100% humidity environment (distilled water), at 37°C [2] (Figure 1).

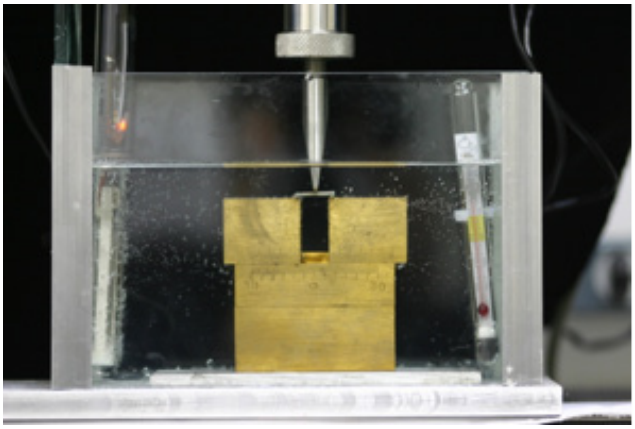

Figure 1-Device used in the 3-point flexure test.

To calculate the bending strength (MPa), the following formula for double layers was used: $\sigma f = 6M/wtt2K(2+ tc/tt + Ettt/Ectc)$ [5].

Statistical analysis:

The statistical analysis was performed with the aid of SPSS 11.0 software for Windows (SPSS Inc., Chicago, IL, USA). Bending strength data (MPa) were submitted to one-way ANOVA and Tukey test (σ=0.05)

Results:

Thermal treatment did not influence on the bending strength of the ceramics/resin cement (p=0.709), Table 3.

Table 3 - Group, Mean (Standard Deviation)

Group	Mean (Standard Deviation)**
NT	19.98 (3.17) ^{A}
T	20.45 (4.67) ^{A}

**Similar letters in the same column indicate no statistically significant differences

Discussion:

One of the characteristics of the ceramic restorations is the limitation of deformation suffered, being a friable material. Because of this property, these restorations exhibit high susceptibility to fracture [6]. During its manufacturing process, the ceramics are loaded by residual tensions. According to Fisher et al. [3], these could be removed by the thermal treatment process, generating an atomic reorganization, which would make the mechanical characterization of these materials more reliable.

Both the microstructure and the composition of the ceramics are controlling factors of the development of mechanical tensions produced by the manufacturing process [4], which would justify the disagreement with the results found by Fischer et al. [3].

The results of this study showed no influence of the thermal treatment, which disagreed with the study of Fischer et al. [3]. Notwithstanding, the methodology of this present study differed from that of Fischer's which could have directly influence on the final resistance.

Further studies to verify the effect of the thermal treatment on specimens undergoing thermomechanical cycling and chemical polishing (glaze), are necessary to understand better the mechanisms by which the catastrophic fractures of ceramic restorations occur.

Conclusion

The thermal treatment did not influence the mean values of bending strength of the ceramics studied.

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Received: 22/11/2012
Accepted: 29/01/2013

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