Strength Behavior of Veneered Zirconia after Different Surface Treatments

Sheila P. Passos[1], Bernie Linke[2] and John A. Nychka[3]

[1] School of Dentistry

Received: 11 December 2015 Accepted: 4 January 2016 Published: 15 January 2016

Abstract

The aim of this study was to evaluate the flexural strength of a veneered zirconia system after different surface treatments as a pre-cementation procedure and before veneering.Methods: Translucent Y-TZP ceramic bars, for four-point bend testing, were prepared and divided considering the compressive (surface treatment for cementation) and lower tensile surfaces (surface treatment for veneering). Two different surface treatments were evaluated: 1-glass interlayer; 2sandblasting + glass interlayer. Four-point bending test data were statistically analyzed using ANOVA. Results:The flexural strength was significantly affected by sandblasting the surface for cementation. Sandblasting + glass interlayer on the surface for veneering combined with sandblasting the surface for cementation presented the highest flexural strength and better strength reliability. Conclusion:Sandblasting + glass interlayer on the surface for veneering combined with sandblasting the surface for cementation presented better results regarding flexural strength and reliability.

Index terms— flexural strength; all-ceramics; Y-TZP; delamination.

1 I. Introduction

o improve the bonding between zirconia core and veneer, surface treatments have been investigated before veneering the zirconia restoration. Such surface treatments include sandblasting [1][2][3] and application of a graded interlayer between the veneer and zirconia or alumina core. 4 Therefore, the combination of airborne-particle abrasion and a graded interlayer between a translucent Y-TZP core and the veneer layer of an all-ceramic system will be evaluated in the present investigation. To our knowledge such a protocol has never been investigated. As external and internal restoration surfaces are sandblasted to improve veneering and cementation bonding, respectively, the aim of this study was to evaluate the flexural strength of a veneered zirconia system after different surface treatments before veneering and as a pre-cementation procedure.

Eighty bar-shaped specimens from partially sintered zirconia (Lava? Plus, 3M ESPE, St. Paul, MN, USA, LOT: 480872) were obtained and sintered (25 mm x 4 mm x 0.7 mm), according to the manufacturer's instructions. Specimens were divided into four groups considering the compressive (surface treatment for cementation) and lower tensile surfaces (surface treatment for veneering). Two different surface treatments were evaluated: 1-glass interlayer; 2sandblasting + glass interlayer. For the first group, the glass layer was applied on the lower surface (veneering surface; tensile surface in the bend test). The second test group had the lower surface sandblasted, and then the glass interlayer was applied on the same surface and sintered. The glass interlayer (SiO_2 -60 mol%; Al_2O_3 -3.13 mol%; CaO -9.4 mol%; Na_2O -14.64 mol%; BaO -6.56 mol%; B_2O_3 -6.27 mol%) was obtained from The Center for Advanced Ceramic Technology, Alfred University.

The porcelain material (VM9, Vita Zanhfabrik, Bad Säckingen, Germany, LOT: 32260) was applied on the lower specimen surface and sintered. The veneer surfaces were leveled and polished using silicon carbide papers in sequence (600, 800 and 1200 grit) under water cooling. Half of the specimens from each coreveneer group were randomly divided into 2 sub-groups (n=20) according to the presence or absence of the sandblasting procedure on the cementation side (Table ??). Air-abrasion, with 30 µm SiO_2 particles (RocatecTM Soft, 3M ESPE, Seefeld, Germany, LOT: 450384) was performed making circular movements at a distance of 10 mm with 2.5 bar pressure for 15 s with aid of a custom made jig, as previously reported. 4 Specimens from each group were investigated by X-ray diffractometry. The relative amount of transformed monoclinic, m, phase (F_M) on the zirconia surfaces was determined as described by Toraya et al. 5 The transformed zone depth (TZD) was determined on the treated zirconia surface and calculated according to the amount of the monoclinic phase. The TZD was obtained based on the equations described by Kosmac et al. 6 The specimens' edges were chamfered using a holding device according to ISO 14704 recommendations. All specimens were submitted to a four-point bending test in a universal testing machine having the veneering porcelain surface under tensile stresses.

The fracture surfaces of the tested specimens were inspected by stereomicroscopy and SEM. The flexural strength (MPa) data were statistically analyzed using two-way analysis of variance (ANOVA). To assess material strength reliability, the flexural strength values were also analyzed using Weibull distribution by the equation:]) (exp[1 0) (m P ? ? ? ? ? ? =

Where P is the probability of failure, ? the fracture strength, ? 0 the characteristic strength at the fracture probability of 63.2%, and m is the Weibull modulus. The values were ranked using a median ranking criteria.

2 III. Results

Monoclinic peaks were not observed after polishing the specimens, which confirms that phase transformation (t-m) occurred only after sandblasting. The reverse transformation (m-t) took place after the sandblasted surfaces for veneering were submitted to the porcelain firing cycle. However, after sandblasting the cementation surface, phase transformation (t-m) was only observed on the cementation side (Fig. 1a). TZD is showed in Figure 1b.

The flexural strength was significantly affected by sandblasting the surface for cementation (P = .008). The group which had the surface for veneering sandblasted + glass interlayer combined with sandblasted cementation surface presented the highest flexural strength and highest strength reliability -Weibull modulus (Table 2). Results of Weibull distribution (63.21% probability of failure) are shown in Table 2 and Figures ?? and 3. The fractured surfaces were analyzed by SEM to identify the origin of failure (Fig. 4b).

3 IV. Discussion

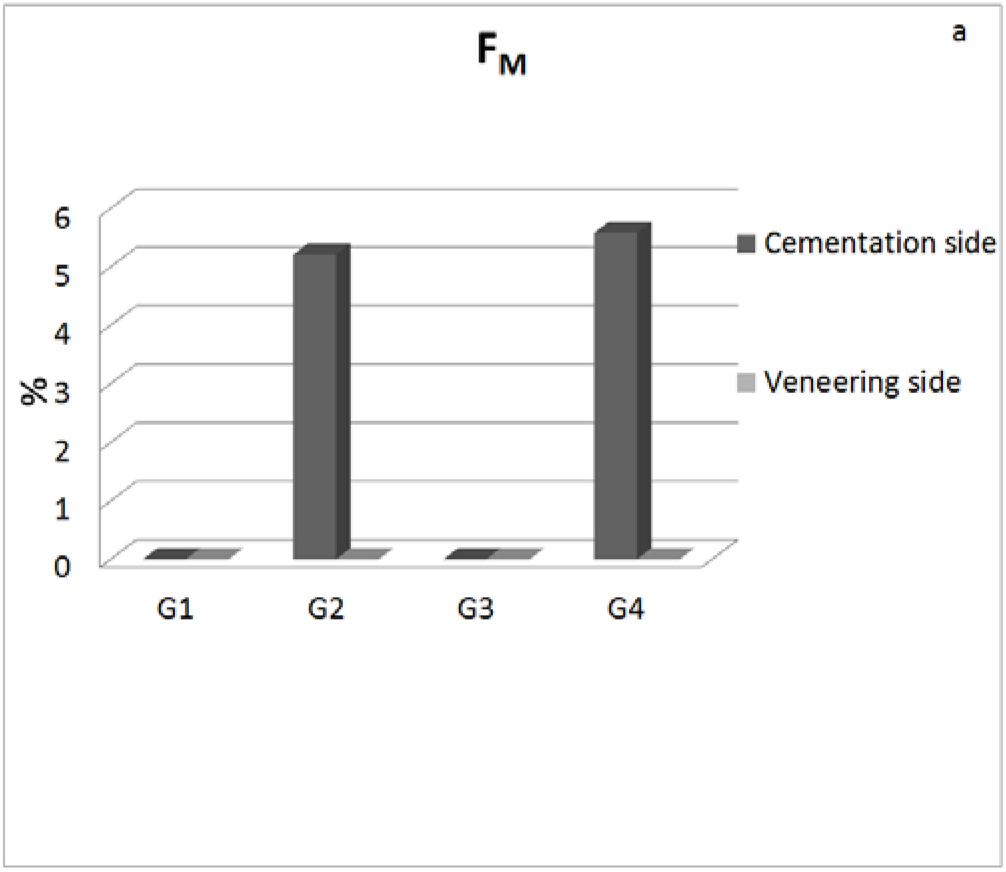
The sandblasted veneering surfaces submitted to the porcelain firing cycle presented no detectable monoclinic phase which confirms the reverse phase transformation generated by the heat procedure (m-t). 3,4 The greatest flexural strength values exhibited from G4 may be attributed to the formation of compressive stresses on the tensile surface (surface for veneering). As a consequence, the YTZ-P crystalline structure was altered (XRD analysis). Partial delamination occurred regardless of the sandblasting the surface for veneering. For the majority of the specimens, volume-distributed flaws were located at the surface where the fracture originated (Fig. 4a,b).

4 V. Conclusions

Sandblasting + glass interlayer on the surface for veneering combined with sandblasting the surface for cementation presented the best treatment option based on the flexural strength and strength reliability exhibited in this study.

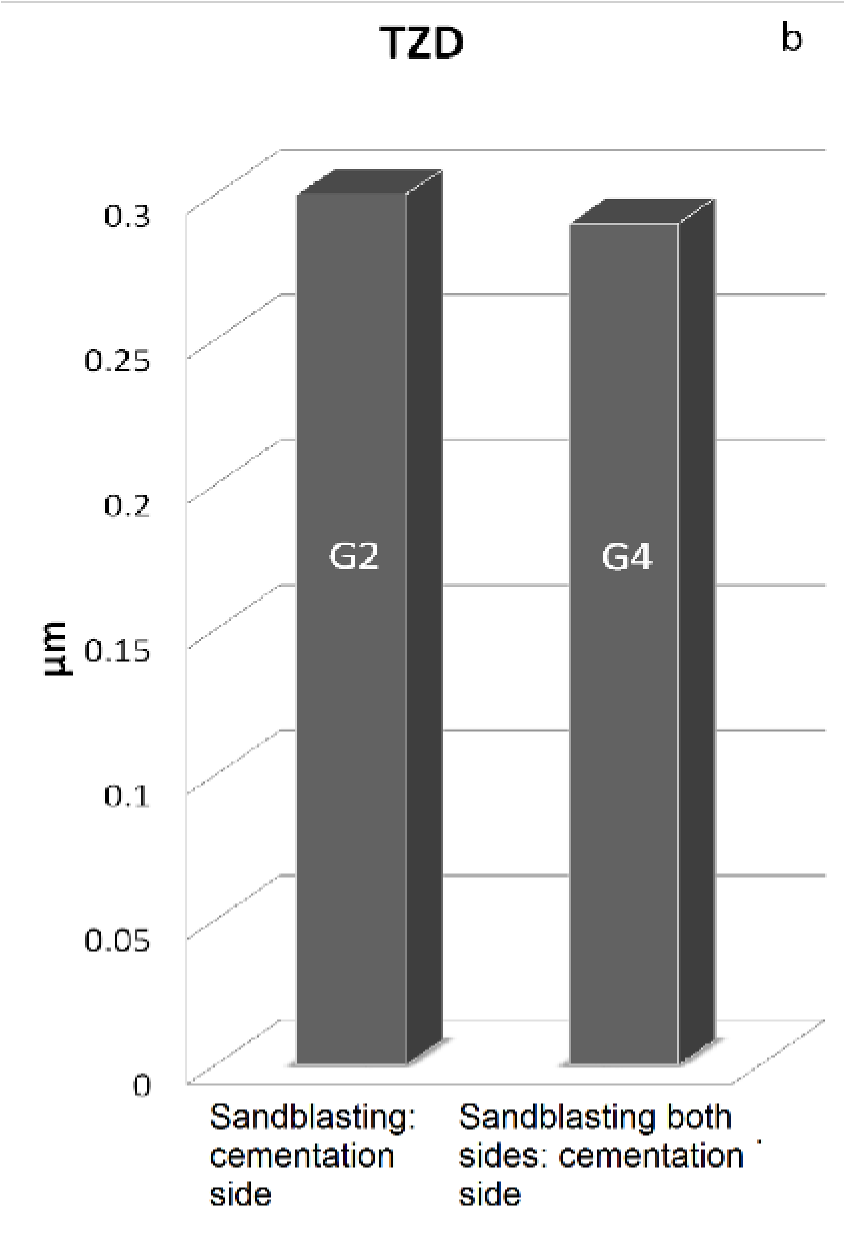
5 Volume XVI Issue III Version I

[1]



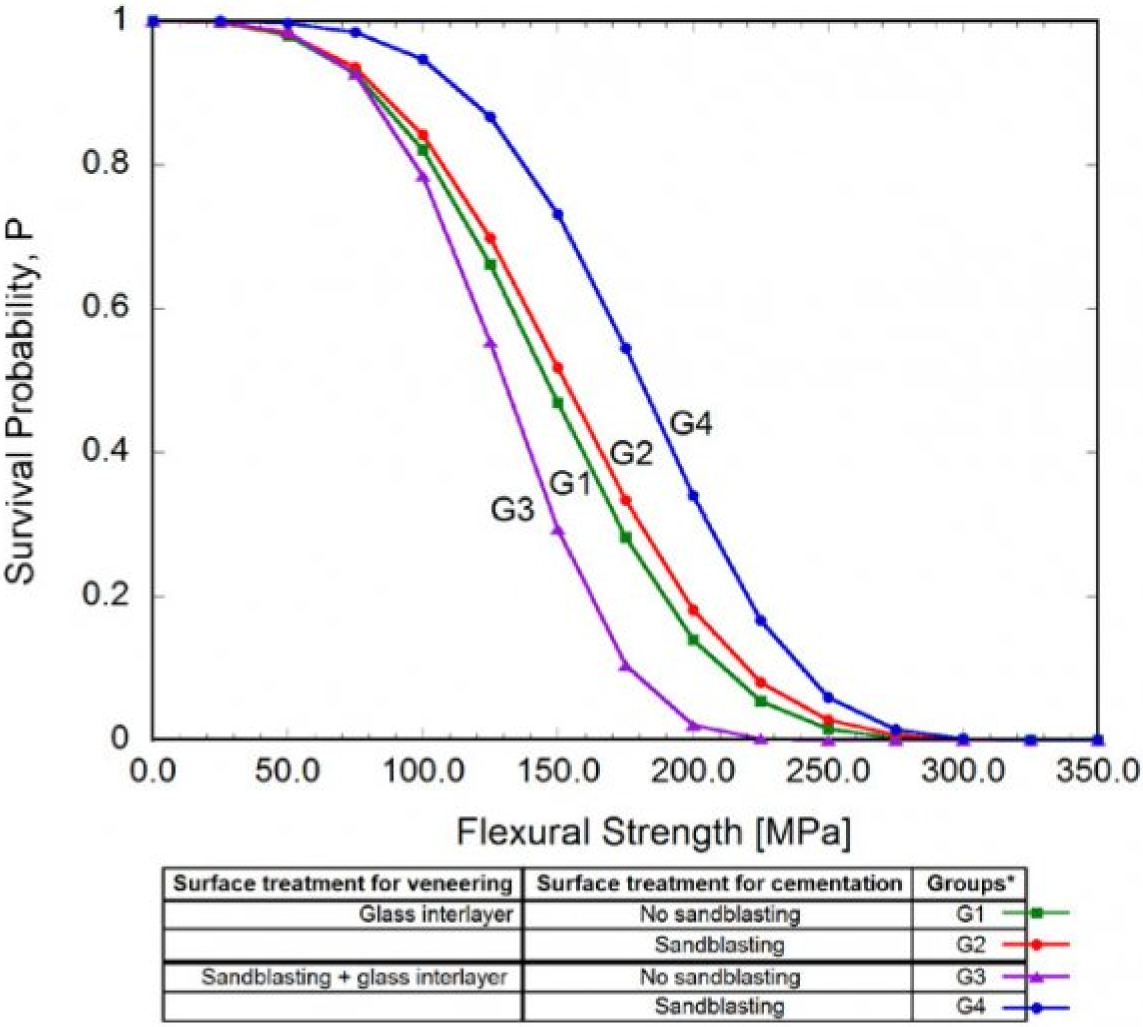
1

Figure 1: Figure 1 :



23

Figure 2: Figure 2 :Figure 3 :



4

Figure 3: Figure 4 :

2

Year 2016

Figure 4: Table 2 :

[Toraya et al. ()] ‘Calibration curve for quantitative analysis of the monoclinic-tetragonal ZrO 2 system by x-ray diffraction’. H Toraya , M Yoshimura , S Somiya . *J Am Ceram Soc* 1984. 67 p. .

[Song et al. ()] ‘Fracture strength and microstructure of Y-TZP zirconia after different surface treatments’. J Y Song , S W Park , K Lee , K D Yun , H P Lim . *J Prosthet Dent* 2013. 110 p. .

[Zhang and Kim ()] ‘Graded structures for damage resistant and aesthetic all-ceramic restorations’. Y Zhang , J W Kim . *Dent Mater* 2009. 25 p. .

[Aboushelib and Wang ()] ‘Influence of crystal structure on debonding failure of zirconia veneered restorations’. M N Aboushelib , H Wang . *Dent Mater* 2013. 29 p. .

[Sato et al. ()] ‘Mechanical properties of dental zirconia ceramics changed with sandblasting and heat treatment’. H Sato , K Yamada , G Pezzotti , G Pezzotti , M Nawa , S Ban . *Dent Mat J* 2008. 27 p. .

[Kosmac et al. ()] ‘X-ray determination of transformation depths in ceramics containing tetragonal ZrO 2’. T Kosmac , R Wagner , N Claussen . *J Am Ceram Soc* 1981. 64 p. .