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Original Article

Fracture Resistance of Ceramic Copings Fabricated from Zirconia and Zirconia-Reinforced Lithium Silicate Glass Ceramic

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Abstract

Background and Aim: In recent years, a variety of CAD/CAM materials have been developed to meet the aesthetic needs of prosthetic restorations. One of the major problems with all-ceramic restorations is their potential for fracture under occlusal and lateral forces. This in vitro study aimed to compare the fracture resistance) FR) of ceramic copings fabricated from zirconia and zirconia-reinforced lithium silicate (ZLS) ceramics.
Materials and Methods: Sixteen identical dies were fabricated from clear epoxy resin, and randomly assigned to two groups (n=8) and coded. The dies were individually scanned by Ceramill scanner, and the copings were fabricated in two groups of Ceramill Zi zirconia and Vita Suprinity ZLS with 0.8 mm equal thickness by Ceramill Motion 2 (Amann Girrbach, Austria) milling machine, and were subsequently sintered. Each restoration was cemented on its respective die using GC Gold Label glass ionomer cement. All specimens were stored in saline at room temperature for 24 hours. They were then mounted in acrylic resin, and subjected to compressive force with 0.5 mm/min crosshead speed applied to the center of their occlusal surface longitudinally in a universal testing machine until fracture. Data were analyzed using T-test (α =0.05).
Results: The force leading to fracture in zirconia group was measured as 749.7 N and in Vita Suprinity group amounted to 234.5N. Thus, the force amounts leading to fracture in sample groups displayed significant differences (p value < 0.001).
Conclusion: Long-term resistance in using 0.8 mm thick copings of Vita Suprinity, cemented with glass ionomer, for clinical applications, is not assured. However, with regards to the most important advantages of ZLS, high esthetic and translucency, to Zirconia, more studies are required to prove clinical application of ZLS with thickness more than 0.8 mm by stronger adhesive bonding systems.
Key Words: CAD-CAM; Zirconia; Fracture Resistance; Zirconia Reinforced Lithium Silicate

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Introduction

All-ceramic restorations have gained significant popularity in recent years due to the drawbacks associated with metal-ceramic restorations, such as metal exposure at the cervical region, discoloration, debonding of the veneering ceramic, and gingival margin discoloration (1). The superior biocompatibility and esthetics of all-ceramic restorations further contribute to their widespread use (1, 2). The selection of an appropriate ceramic material for dental restorations is influenced by several factors, including the required esthetic outcome, mechanical properties, type and location of the restoration, as well as the design of the tooth preparation (3, 4).

While ceramic materials are highly favorable for their esthetic properties, they are inherently brittle. This brittleness can be mitigated by incorporating a supportive core material. Such a core may consist of metal, a high-strength but less esthetic ceramic, or a structural framework designed to enhance the overall strength and durability of the restoration (5). In these cases, the core is typically veneered with a high-translucency ceramic, such as feldspathic ceramic, to enhance the esthetic appearance and mimic the natural gloss of teeth (6, 7). However, one of the main disadvantages of veneered restorations is the potential chipping of the veneering material, which can lead to failure of the restoration (8, 9, 10). To overcome these challenges, monolithic restorations were introduced (11, 12, 13), offering advantages such as eliminating the contact between the core and veneering layer, thereby reducing the risk of chipping (14, 15). Furthermore, monolithic restorations preserve more tooth structure, are more cost-effective, and allow for a more conservative preparation design [16]. Advancements in digital technologies have played a significant role in the growing adoption of monolithic restorations, primarily due to their more efficient and expedited fabrication process (17, 18).

Among the materials used for monolithic restorations, lithium disilicate (LDS) and zirconia are commonly chosen for their high fracture resistance (FR) (19, 20). Zirconia, in particular, offers excellent biocompatibility and mechanical properties, but its matte and opaque appearance limits its ability to replicate the translucency of natural teeth (21, 22). Although monolithic zirconia demonstrates superior fracture resistance compared to veneered zirconia and metal-ceramic restorations (20, 23), it continues to present challenges in achieving optimal esthetic outcomes (24).

On the other hand, silicate ceramics, such as lithium disilicate, offer superior translucency, low thermal conductivity, and excellent tissue compatibility (25). However, they are also brittle, and their fabrication requires careful consideration of thickness (26). Lithium disilicate (LDS) ceramics exhibit enhanced fracture resistance relative to earlier generations of silicate-based ceramics (27), thereby making them a suitable choice for monolithic restorations. Zirconia-reinforced lithium silicate (ZLS) ceramics, introduced to address the limitations of LDS in terms of strength, offer a promising alternative. ZLS is an LDS ceramic reinforced with 10% zirconia, which enhances its mechanical properties. The zirconia reinforcement helps prevent crack propagation and improves the overall strength of the glass matrix (28, 29). ZLS combines the favorable esthetic appearance of glass ceramics with enhanced mechanical properties due to the zirconia reinforcement (4, 30).

Given the differences in the mechanical properties and esthetic potential of zirconia and ZLS ceramics, it is important to compare their fracture resistance under in vitro conditions. This comparison is clinically relevant because the fracture resistance of these materials directly impacts their durability and performance in restorations, influencing both the longevity of the treatment and patient outcomes. Therefore, the aim of this study is to compare the fracture resistance of zirconia and ZLS ceramics for the fabrication of ceramic copings.

Materials and Methods

This study was approved by the Ethics Committee of the Faculty of Dentistry, Tehran Medical Sciences, Islamic Azad University, Tehran, Iran. The study is based on a thesis submitted to the Faculty of Dentistry, Tehran Medical Sciences, Islamic Azad University (Thesis Number: 89266).

The sample size was calculated to be 8 in each of the two groups according to a study by Kashkari et al, (31) assuming α=0.05, β=0.2, and standard deviation values of 800 and 1100 N in the two groups, to find a significant difference equal to 1500 N between the two groups.

Initially, a standard stainless steel die was fabricated using a milling machine. The die featured a base diameter of 5 mm, a height of 7 mm, an anti-rotational groove, a 10-degree taper, and a 90-degree shoulder margin (Figure 1).

A special tray was then fabricated on the standard die using auto-polymerizing acrylic resin (Akropars, Tehran, Iran). Afterwards, 16 impressions were made from the standard die using the fabricated special tray and a light-body impression material (Speedex; Coltene AG, Switzerland). The impressions were poured with an epoxy resin material (Clear Epoxy; Berlin, Germany). After setting, epoxy resin dies were separated from the impressions, and those with voids were excluded and replaced. Epoxy resin dies were then randomly assigned to two groups (n=8) and coded. The dies were individually scanned by a scanner (Ceramill Map400, Amann Girrbach, Koblach, Vorarlberg, Austria). The copings were fabricated in two groups of zirconia (Cermill Zi white, Amann Girrbach, Koblach, Austria) and ZLS ceramic (Vita-Suprinity, Vita-Zahnfabrik, Bad Säckingen, Germany) with equal thickness of 0.8 mm by Ceramill milling machine (Motion 2, Amann Girrbach, Koblach, Austria) (Figure 2) .

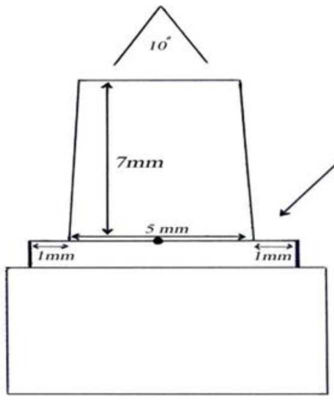

Figure 1. Prepared dies design

Figure 2. Prepared copings design

They were then sintered (Protherm furnace, Dental MoS Series, Ankara, Turkey) according to the manufacturer's instructions. Each restoration was then cemented on its respective coded die by using glass ionomer cement (GC Gold Label; Tokyo, Japan) as instructed by the manufacturer, and held in place with gentle finger pressure for 5 minutes to allow setting of the cement (32). Excess cement was removed by an explorer. All specimens were then stored in saline at room temperature for 24 hours.

The specimens were then individually mounted in auto-polymerizing acrylic resin (Akropars, Tehran, Iran) in a metal ring, and transferred to a universal testing machine (Zwick, Germany). They were subjected to compressive load applied to the center of their occlusal surface at a crosshead speed of 0.5 mm/minute longitudinally. The force increased from 0 N until fracture (Figure 3).

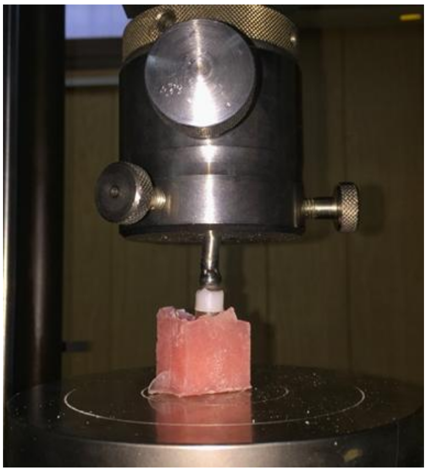

Figure 3. Universal testing machine

The mode of fracture was also evaluated. [Type 1: Formation of an extensive crack in the restoration, type 2: cohesive fracture or fracture within the restoration, type 3: adhesive fracture or fracture at the tooth structure and restoration interface, and type 4: longitudinal fracture of tooth and restoration (33)].

The mean and standard deviation of force causing fracture of specimens were calculated in the two groups. The normality of data distribution was analyzed by the Kolmogorov-Smirnov test, which showed normal distribution of data. Thus, t-test was applied to compare the two groups regarding FR at 0.05 level of significance

Results

This study assessed the FR of zirconia and Vita Suprinity ZLS copings in two groups (n=8) that were subjected to compressive force in a universal testing machine. The mean FR was 749.7± 85.2 N in the zirconia and 23.5±35.1 N in the Vita Suprinity ZLS group (Table 1, Figure 1). T-test analysis showed significant differences between two groups (P<0.001) (Table 1).

Table1. Mean and standard deviation of FR (N) in the zirconia and Vita Suprinity ZLS ceramic groups

Min	Max	SD	Mean	Fracture resistance / Material
643.75	864.59	85.28213	749.7525	**Zirconia**
181.44	276.97	35.12927	234.5775	**Vita suprinity**
		P value < 0.001		

There was no significant difference in failure type between the groups, and in both groups, Type 3 failure was observed. (Type 1: wide internal restoration crack, Type 2: cohesive fracture or fracture within the restoration, Type 3: adhesive fracture or failure between the tooth structure and the restoration, and Type 4: longitudinal fracture of the tooth and restoration) (26)

Discussion

Ceramic restorations are extensively used as a more esthetic alternative to metal-ceramic restorations. Different parameters should be taken into account in selection of ceramic materials, such as esthetics, mechanical and physical properties, etching ability for bonded restorations, type and location of reconstruction, finish line design, and parafunctional habits (3).

Fracture of all-ceramic restorations under occlusal and lateral forces is one of their major drawbacks (26). The FR of ceramic restorations depends on their microstructure, fatigue loading, fabrication technique, preparation design, and luting technique (34). This study compared the FR of all-ceramic crowns with zirconia and ZLS copings and showed significantly higher FR of zirconia (749.7 N) than Vita Suprinity ZLS ceramic (234.6 N).

Guess's type 3 fracture was noted in both groups (26). In a study by Al-Akhali et al, [34] in 2017, the fracture modes were types 1 and 3 in all groups. The modulus of elasticity of the supporting core affects the FR. Thus, understanding the influence of different core materials on fracture behavior remains crucial. Dies with low modulus of elasticity are more suitable for simulation of in vivo conditions in FR testing. Therefore, epoxy resin dies were used in the present study since they have a modulus of elasticity closer to that of dentin, compared with brass dies. One main difference between clinical and in vitro conditions is the existence of a hybrid layer between dentin and cement, which influences mechanical properties and alters bond strength. Although this factor introduces a limitation, the standardized study design ensures a reliable comparison between the groups (26).

Mohamed et al. (35) in 2020 reported the FR of ZLS crowns to be 1093 N before aging. This discrepancy may stem from differences in bonding agents, crown thickness, or experimental conditions. Gomes et al. (36) in 2016 reported the FR of implant-supported Vita Suprinity monolithic crowns to be 1626 N. The increased thickness of monolithic crowns likely contributed to their superior FR, reinforcing the importance of material thickness in restoration longevity. They also found that the axial and occlusal gaps of ZLS restorations were within the clinically acceptable range (< 122 µm), and stated that optimally high adaptation of this restoration had a direct effect on its FR.

Al-Akhali et al, (34) in 2017 reported the FR of Vita Suprinity occlusal veneers to be 1076.8 N before thermomechanical loading. The higher survival rate and FR value in their study, compared with the present results, may be due to the application of an etch and rinse bonding system on the enamel in their study. This highlights the potential role of adhesive bonding protocols in enhancing restoration performance. Although some studies refuted the effect of cementation technique on long-term durability of all-ceramic restorations. some others showed that the cementation technique affected the survival rate and FR of these restorations.

For this purpose, Addazio et al, (37) in 2020 compared the FR of ZLS crowns cemented with conventional glass ionomer cement and an adhesive system. They showed that both cements yielded acceptable FR within the clinically acceptable range; however, the adhesive cement yielded a higher FR against compressive forces for this material. The present study's use of conventional GI cement may have influenced the bond stability, particularly in thinner restorations. However, according to the obtained FR values, it appears that glass ionomer cement created an unstable and insufficient bond between the abutment and copings, and ZLS restorations with less than 1 mm thickness require an adhesive system for cementation to ensure their long-term durability. This finding suggests that future research should focus on evaluating different adhesive systems and their impact on ZLS restorations of varying thicknesses.

In general, the effect of bond strength is superior to the difference between materials; however, the mechanical behavior of tooth-restoration complex, which includes the restorative material, adhesive system, and tooth, is not easily predictable (34). In general, a wide range of values have been reported for FR of ZLS ceramics due to the existing challenges against the measurement of FR of dental ceramics (38). Further studies should investigate standardized testing protocols to reduce variability in FR measurements.

In the present study, although zirconia showed higher FR than ZLS ceramic, ZLS can undergo chemical aging with hydrofluoric acid due to its silica-based structure and presence of a glass matrix in its composition, and form a stronger bond with resin cement (39). In contrast, zirconia cannot be etched with the commonly used surface acidification methods (i.e., application of hydrofluoric acid) due to its polycrystalline chemical structure, and requires mechanical surface treatments and intraoral sandblasting and subsequent silanization for etching (37). This difference in bonding mechanisms highlights the importance of selecting the appropriate cementation protocol based on the restorative material.

Several studies regarding the abrasive effect of porcelain have reported that ceramics have higher capacity to abrade their antagonistic teeth compared with other restorative materials. Moreover, material hardness has a direct correlation with wear of the antagonistic teeth (40). Thus, lower hardness of ZLS than zirconia ceramic (when used as monolithic) may be considered as an advantage since it would cause less wear of the antagonistic teeth (especially when the antagonistic teeth are natural teeth).

In general, it may be stated that monolithic crowns can better tolerate forces than bi-layered crowns (36). Although the material strength of zirconia is higher than that of ZLS, for optimal and ideal esthetic appearance of zirconia restorations, zirconia should be necessarily used as a coping with a feldspathic porcelain layering; whereas, glass ceramics such as ZLS have optimal esthetics in monolithic form due to their silica content, and there is no need for porcelain layering and subsequent complications such as chipping or delamination of porcelain.

Considering the abovementioned advantages and the most important superiority of ZLS to zirconia, i.e., optimal esthetics and translucency, Future studies should evaluate the long-term performance of ZLS crowns in clinical settings, particularly in cases requiring minimal thickness.

The study had several limitations that may have influenced the clinical interpretation and generalizability of the findings. A relatively small sample size was used, which restricted the scope of analysis. Conventional epoxy resin was applied instead of dentin-like fiber-reinforced epoxy resin, which had a different modulus of elasticity compared to dentin and affected fracture resistance (FR), as ceramics remained rigid and brittle while dentin exhibited elasticity and deformation under occlusal forces. Restoration margins were evaluated visually without the use of scanning electron microscopy, which may have limited the accuracy in detecting marginal gaps. Specimens were cemented using finger pressure, potentially introducing variability. Additionally, the CAD/CAM system was unable to optimally scan sharp 90-degree angles in shoulder margins, leading to increased cement thickness at these internal angles and a subsequent decrease in FR of copings. Resin cements were not utilized due to cost constraints, despite their ability to chemically bond tooth structure to ceramic restorations, reinforcing the dentin-restoration complex and enhancing FR. Furthermore, physiological tooth mobility was not simulated, which may have affected the absorption and distribution of masticatory forces in the alveolar bone, impacting the results.

Conclusion

It can finally be concluded that zirconia copings demonstrated significantly higher fracture resistance compared to ZLS copings. However, despite this difference in strength, the fracture mode remained similar in both groups, indicating comparable failure patterns.

References

1. Habibi Y, Dawid MT, Waldecker M, Rammelsberg P, Bömicke W. Three-year clinical performance of monolithic and partially veneered zirconia ceramic fixed partial dentures. J Esthet Restor Dent. 2020;32(4):395-402.

2. Konstantinidis I, Trikka D, Gasparatos S, Mitsias ME. Clinical outcomes of monolithic zirconia crowns with CAD/CAM technology: a 1-year follow-up prospective clinical study of 65 patients. Int J Environ Res Public Health. 2018;15(11):2523.

3. Rauch A, Schrock A, Schierz O, Hahnel S. Material selection for tooth-supported single crowns—a survey among dentists in Germany. Clin Oral Investig. 2021;25: 283-93.

4. Belli R, Wendler M, de Ligny D, Cicconi MR, Petschelt A, Peterlik H, et al. Chairside CAD/CAM materials. Part 1: Measurement of elastic constants and microstructural characterization. Dent Mater. 2017;33(1):84-98.

5. Campbell SD. A comparative strength study of metal ceramic and all-ceramic esthetic materials: modulus of rupture. J Prosthet Dent. 1989;62(4):476-9.

6. Guazzato M, Albakry M, Ringer SP, Swain MV. Strength, fracture toughness and microstructure of a selection of all-ceramic materials. Part II. Zirconia-based dental ceramics. Dent Mater. 2004;20(5):449-56.

7. Jurišić S, Jurišić G, Knezović Zlataric D. In vitro evaluation and comparison of the translucency of two different all-ceramic systems. Acta Stomatol Croat. 2015; 49(3):195-203.

8. Güngör MB, Nemli SK. Fracture resistance of CAD-CAM monolithic ceramic and veneered zirconia molar crowns after aging in a mastication simulator. J Prosthet Dent. 2018;119(3):473-80.

9. Gehrt M, Wolfart S, Rafai N, Reich S, Edelhoff D. Clinical results of lithium-disilicate crowns after up to 9 years of service. Clin Oral Investig. 2013;17:275-84.

10. Zhao K, Pan Y, Guess PC, Zhang XP, Swain MV. Influence of veneer application on fracture behavior of lithium-disilicate-based ceramic crowns. Dent Mater. 2012;28(6):653-60.

11. Bonfante EA, Suzuki M, Lorenzoni FC, Sena LA, Hirata R, Bonfante G, et al. Probability of survival of implant-supported metal ceramic and CAD/CAM resin nanoceramic crowns. J Prosthet Dent. 2015;31(8):e168-77.

12. Harada A, Nakamura K, Kanno T, Inagaki R, Örtengren U, Niwano Y, et al. Fracture resistance of computer-aided design/computer-aided manufacturing-generated composite resin-based molar crowns. J Prosthet Dent. 2015; 123 (2):122-9.

13. Beuer F, Stimmelmayr M, Gueth JF, Edelhoff D, Naumann M. In vitro performance of full-contour zirconia single crowns. Dent Mater. 2012;28(4):449-56.

14. Lameira DP, De Souza GM. Fracture strength of aged monolithic and bilayer zirconia-based crowns. Biomed Res Int. 2015;2015:1-8.

15. Zhao K, Wei YR, Pan Y, Zhang XP, Swain MV, Guess PC. Influence of veneer and cyclic loading on failure behavior of lithium disilicate glass-ceramic molar crowns. Dent Mater. 2014;30(2):164-71.

16. Nordahl N, von Steyern PV, Larsson C. Fracture strength of ceramic monolithic crown systems of different thickness. J Oral Sci. 2015;57(3):255-61.

17. Wittneben JG, Wright RF, Weber HP, Gallucci GO. A systematic review of the clinical performance of CAD/CAM single-tooth restorations. Int J Prosthodont. 2009; 22(5): 481-90.

18. Mehl C, Harder S, Byrne A, Kern M. Prosthodontics in digital times: a case report. J Prosthet Implant Dent. 2013; 44:29-36.

19. Sun T, Zhou S, Lai R, Liu R, Ma S, Zhou Z, et al. Load-bearing capacity and the recommended thickness of dental monolithic zirconia single crowns. J Dent Mater. 2014; 35:93-101.

20. Zhang Y, Mai Z, Barani A, Bush M, Lawn BJ. Fracture-resistant monolithic dental crowns. Dent Mater. 2016;32(3):442-9.

21. Thompson JY, Stoner BR, Piascik JR, Smith RJ. Adhesion/cementation to zirconia and other non-silicate ceramics: where are we now? Dent Mater. 2011;27(1):71-82.

22. Elsaka SE. Influence of surface treatments on the surface properties of different zirconia cores and adhesion of zirconia-veneering ceramic systems. J Dent Mater. 2013; 29(10):e239-e51.

23. Zesewitz TF, Knauber AW, Nothdurft FP. Fracture resistance of a selection of full-contour all-ceramic crowns: an in vitro study. J Prosthet Dent. 2014;27(3):264-6.

24. Miyazaki T, Nakamura T, Matsumura H, Ban S, Kobayashi T. Current status of zirconia restoration. J Oral Prosthet. 2013;57(4):236-61.

25. Lawn BR. Ceramic-based layer structures for biomechanical applications. J Compos Mater Sci. 2002;6 (3):229-35.

26. Guess PC, Schultheis S, Wolkewitz M, Zhang Y, Strub JR. Influence of preparation design and ceramic thicknesses on fracture resistance and failure modes of premolar partial coverage restorations. J Prosthet Dent. 2013; 110 (4):264-73.
27. Elsaka SE, Elnaghy AM. Mechanical properties of zirconia reinforced lithium silicate glass-ceramic. Dent Mater. 2016;32(7):908-14.
28. Schwindling FS, Rues S, Schmitter M. Fracture resistance of glazed, full-contour ZLS incisor crowns. J Oral Prosthodont. 2017;61(3):344-9.
29. Manicone PF, Iommetti PR, Raffaelli L. An overview of zirconia ceramics: basic properties and clinical applications. J Oral Dent. 2007;35(11):819-26.
30. Awad D, Stawarczyk B, Liebermann A, Ilie N. Translucency of esthetic dental restorative CAD/CAM materials and composite resins with respect to thickness and surface roughness. J Prosthet Dent. 2015;113(6):534-40.
31. Kashkari A, Yilmaz B, Brantley WA, Schricker SR, Johnston WM. Fracture analysis of monolithic CAD-CAM crowns. J Esthet Restor Dent. 2019;31(4):346-52.
32. Blatz MB, Sadan A, Kern M. Resin-ceramic bonding: a review of the literature. J Prosthet Dent. 2003;89(3):268-74.
33. Kern M, Fechtig T, Strub JR. Influence of water storage and thermal cycling on the fracture strength of all-porcelain, resin-bonded fixed partial dentures. J Prosthet Dent. 1994;71(3):251-6.
34. Jalalian E, Aletaha NS. The effect of two marginal designs (chamfer and shoulder) on the fracture resistance of all ceramic restorations, Inceram: an in vitro study. J Prosthet Restor. 2011;55(2):121-5.
35. Mohamed MS, Mohsen CA, Katamish H. Impact of chemical aging on the fracture resistance of two ceramic materials: zirconia-reinforced lithium silicate and lithium disilicate ceramics. J Oral Maxillofac Surg. 2020;8(D):189-93.
36. Gomes RS, Souza CMCd, Bergamo ETP, Bordin D, Del Bel Cury AA. Misfit and fracture load of implant-supported monolithic crowns in zirconia-reinforced lithium silicate. J Oral Sci. 2017;25:282-9.
37. D'Addazio G, Santilli M, Rollo ML, Cardelli P, Rexhepi I, Murmura G, et al. Fracture resistance of zirconia-reinforced lithium silicate ceramic crowns cemented with conventional or adhesive systems: An in vitro study. J Prosthet Dent. 2020;13(9):2012.
38. Ottoni R, Griggs JA, Corazza PH, Della Bona Á, Borba MJ. Precision of different fatigue methods for predicting glass-ceramic failure. J Mech Behav Biomed Mater. 2018;88:497-503.
39. Borges GA, Sophr AM, De Goes MF, Sobrinho LC, Chan DC. Effect of etching and airborne particle abrasion on the microstructure of different dental ceramics. J Prosthet Dent. 2003;89(5):479-88.
40. Olivera AB, Marques MM. Esthetic restorative materials and opposing enamel wear. J Oral Dent. 2008; 33(3): 332-7.