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Application of Low-Level Laser Therapy in Veneer Repair of Lithium Disilicate and Y-TZP Restorations

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ABSTRACT

To assess intra oral repair of Lithium Disilicate ceramics (LDC) and Yttria Stabilized Tetragonal Zirconia Polycrystal (Y-TZP) using low level laser therapy (LLLT) in comparison to conventional conditioning modalities on repair bond strength of composite resin bonded to ceramic structure. Fifty specimens of LDC and fifty samples of Y-TZP were used. Discs were prepared form each group having a diameter 6 mm and thickness of 2 mm and conditioned using different regimes. Group 1 and 6 were surface treated with bur, group 2 and 7 were conditioned with Nd-YAG (NYL), group 3 and 8 surface was treated with Er,Cr:YSGG (ECL), group 4 and 9 with hydrofluoric acid + salinization (HF+S) and group 5 and 10 were conditioned with Al2O3 air abrasion (AA). A single layer of Heliobond was scrubbed on the conditioned surface and bonded with composite resin. For shear bond strength testing the specimens were placed in a universal testing machine. A stereomicroscope at 40x magnification was used to analyse failure pattern. The mean repair bond strength was calculated using ANOVA and Tukey's post hoc test at a significance level of ($p < 0.05$). The highest repair bond strength observed in LDC was (19.57±3.58 MPa) in group 4 whereas, the lowest score was displayed in Group 3 (11.88±1.98 MPa). Similarly, in Y-TZP the highest repair SBS values were presented in group 10 (air abrasion) (20.32±3.21) and the lowest SBS values were exhibited by bur treated group 1 (12.25±2.33). Failures in group 1, group 2, group 3, group 6, group 7 and group 8 were dominantly adhesive. Whereas, failures in group 4, group 5, group 9 and group 10 were cohesive. HF acid with salinization remains gold standard for conditioning of LDC. AA with salinization is the most effective method to condition YTZP ceramics for better repair bond scores. Alternate methods of conditioning using LLLT (NYL and Er,Cr:YSGG) needs further investigation.

KEY WORDS: ER,CR:YSGG, ND-YAG, REPAIR BOND STRENGTH, LITHIUM DISILICATE CERAMICS, YTTRIA STABILIZED TETRAGONAL ZIRCONIA POLYCRYSTAL.

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INTRODUCTION

Yttria Stabilized Tetragonal Zirconia Polycrystals(Y-TZP) ar used as crowns, long span fixed partial dentures and veneers because of their mechanical properties, biocompatibility and high flexural strength (Akyil et al., 2010). Zirconia Y-TZP is not translucent like natural teeth hence, to enhance its appearance it requires veneering of ceramic layer (Cristoforides et al., 2012). This ceramic layer tends to get fractured or chipped from cuspal tips or occlusal edges. This results in functional discomfort and aesthetic compromise for the patient (Galvão et al., 2018). It's not always possible to change fractured prosthesis as it is time consuming, expensive, and damaging to surrounding tissues (Kirmali et al., 2015). Therefore, use of conditioners, primers and adhesion promoters along with composite resins are used to improve the longevity of the restoration (Kirmali et al., 2015; Özcan et al., 2013). Conventionally fractures in lithium Disilicate (LDC), porcelain feldspathic and leucite, are repaired by conditioning the surface with hydrofluoric (HF) acid along with salinization (Colares et al., 2013). The method is well established to promote adhesion of resin-based material. However, HF acid is dangerous as it increases the risk of tissue necrosis and burns. Moreover, its effect on Y-TZP is still controversial as it does not allow topographical changes (Kirkpatrick et al., 1995; Özcan et al., 2013).

Repair fracture of zirconia Y-TZP is challenging. To improve adhesion, use of both chemical and mechanical conditioning regimes are considered. These regimes may range from sand blasting the repairing surface with Al2O3 to surface conditioned with bur and application of silane coupling agents. All these conditioning regimes improve wettability and surface energy of Y-TZP, but their efficacy and effectiveness are still controversial, (Ozcan et al 2013, Kirmali et al., 2015, Galvao et al 2018). Lately, use of lasers Er,Cr:YSGG (ECL) and Nd,YAG (NYL) for surface treating LDC has displayed convincing results (Alkhudhairy et al., 2019a; Vohra et al., 2019). Moreover, ECL along with NYL have demonstrated conclusive outcomes on conditioning of dentin and enamel surface (Alkhudhairy et al. 2018a, 2018b, 2019b, 2019c). In the authors knowledge from indexed literature, limited evidence is available on surface treatment of zirconia ceramic with the purpose of repair by composite resin. It is hypothesized surface treated with low level laser therapy (LLLT) will exhibit comparable repair bond strength to conventional surface treated regimes. Therefore, the aim of the present in vitro study was to assess repair of LDC and Y-TZP using LLLT in comparison to conventional conditioning modalities on repair shear bond strength of composite resin bonded to ceramic structure.

MATERIAL AND METHODS

In the current study hundred samples i.e., fifty specimens of lithium Disilicate ceramics (LDC) (IPS Emax Press; Ivoclar/Vivadent, Schaan, Liechtenstein) and fifty samples of Yttrium-Stabilized Tetragonal Zirconia Polycrystal ceramic (Y-TZPC) (Noritake Alliance, Noritake Co., Nagoya, Japan) were used. Discs were prepared form each group having diameter 6mm and thickness 2mm. Before the surface treatment all hundred discs were cleaned ultrasonically using 96% isopropanol for duration of 3 min (Vohra et al., 2019) and air dried. Based on surface conditioning method LDC and Y-TZPC discs were divided into ten groups (n=10 each) The present study followed CRIS (Checklist for reporting In vivo studies) guidelines. Specimens from group 1 were surface treated using diamond bur 30-µm-grit (Kerr Corporation, USA) 10 strokes under running water. Similarly, Cimara grinding bur (Cimara, Zircon, Voco, GmbH, Germany) for Y-TZPC was used 10 strokes for group 6. Samples from group 2 and 7 were surface conditioned using ECL (Millennium; Biolase Technology, Inc., San Clemente, CA, USA) at wavelength 2.78 micro-meter, 3.75 W power and 15 Hz frequency with air water ratio of 90-70% in a non-contact circular motion using tip MZ8 for 60 sec.

Specimens from group 3 and 8 were surface treated using NYL (Hoya ConBio Delight, Sweden & Martina, Padova, Italy) at wavelength 1064 nm. The laser was used perpendicular to the bonding surface from a distance of 2mm for a duration of 60 sec at 150 mJ, 10 Hz and 3 W for a duration of 60 sec in a non-contact circular motion using 320-µm quartz optical fibre Specimens from group 4 and 9 were conditioned using 9.5% hydrofluoric acid gel (etching gel Ivoclar, vivadent) for a duration of 1min, washed 20 sec and oil free air dried. Salinization was done using coupling agent (Monobond Plus ceramic primer Ivoclar vivadent) in a single layer for 60 sec and air dried. Specimen from group 5 and 10 were surface treated using aluminium trioxide (Al2O3) silicate particles (CoJet system; 3M ESPE, St. Paul, MN) maintaining a pressure of 2.3bar in a non-contact position from a distance of 8mm, for a duration of 1 min. After AA all specimens were washed under running water. After conditioning of surfaces samples from groups 1,4,5 and 6,9,10 received a coating of silane (Monobond Plus ceramic primer Ivoclar vivadent) a single layer for 60 sec and air dried. No silane coupling agent was applied on lased groups. Samples were cleaned with isopropanol for 180 sec and oil free air dried. A single layer of Heliobond (Ceramic Repair N) was scrubbed on the conditioned surface and light cured for 10 sec (Bluephase G2, Ivoclar,Vivadent). The repaired surface was bonded to composite resin (Multicore flow; Ivoclar/ Vivadent) incrementally using a tofelmire matrix holder at a height of 5mm and cured 20sec.

To replicate oral conditions all specimens were shifted to a thermocycler (Mini Opticon Real-Time PCR System, BioRad, USA) between 5C to 60°C for 30sec transfer time 5 sec. For shear bond strength testing the specimens were placed in a Universal testing machine (Zwick Roell Z2.5 MA 18-1-3/7 ulm, Germany) at a cross head speed of 1ml/min and 2.5KN force perpendicular to the bonded surface until repair failure. The repair bond strength was measured in MPa (Megapascals). A stereomicroscope at 40x magnification was used to analyse failure pattern. Failure type was categorized into adhesive, cohesive and admixed failure type. The data were normally distributed according to Kolmogorov–Smirnov test (a=0.05). The mean repair bond strength was calculated using ANOVA and Tukey's post hoc test at a significance level of ($p < 0.05$). Data was charted using statistical program for social science (SPSS version 21, Inc., Chicago, US)

RESULTS AND DISCUSSION

A normal distribution of data was observed in the present study. Table 1 displays repair SBS values in Lithium Disilicate (LD) and Zr Y-TZP type ceramics. The highest repair bond strength observed in LDC was (19.57 ± 3.58) in group 4 Hydrofluoric acid + salinization whereas, the lowest score was displayed in Group 3 laser irradiated using Nd-YAG (11.88 ± 1.98). Similarly, in Y-TZP the highest repair SBS values were presented in group 10 air abrasion (20.32 ± 3.21) and the lowest SBS values were exhibited by bur treated group 1 (12.25 ± 2.33).

Table 1. Comparison of means and SD for repair bond strength values among study groups using ANOVA and Tukey multiple comparisons test

Type of Material	Surface treatment	Mean ± SD Mpa	P-value!
	Group 1: Bur treatment (Control)	12.27 ± 2.11^{a}	
	Irradiated using Er,Cr:YSGG (ECL)	13.52 ± 2.68^{a}	
Lithium Disilicate Ceramics (LDC)	Group 3: Laser Irradiated using Nd-YAG	11.88 ± 1.98^{a}	
	Group 4: Hydrofluoric acid + salinization	19.57 ± 3.58^{c}	<0.05
	Group 5: Air Abrasion	16.44 ± 3.82^{c}	
	Group 6: Bur treatment (Control)	12.25 ± 2.33^{a}	
Zirconia Y-TZP	Group 7: Laser Irradiated using Er,Cr:YSGG	14.25 ± 2.24^{a}	
	Group 8: Laser Irradiated using Nd-YAG laser	13.74 ± 1.54^{a}	<0.05
	Group 9: Hydrofluoric acid + salinization	18.66 ± 3.44^{c}	
	Group 10: Air Abrasion	20.32 ± 3.21^{c}	

Different upper script letters in individual materials indicate statistical differences ($p < 0.05$).
! Showing significant difference among study group (ANOVA)

Based on the conditioning regimes repair SBS values of group 1, group 2, group 3, group 6, group 7 and group 8 were comparable p>0.05. Similarly, repair SBS in group 4, group 5, group 9 and group 10 were also found to be comparable p>0.05. For bond strength values, analysis of variance (ANOVA) showed significant difference among all study groups (p>0.05). Failure modes observed among the de-bonded specimens are presented in table 2. Most of the failures in group 1, group 2, group 3, group 6, group 7 and group 8 were dominantly adhesive. Whereas, failures in group 4, group 5, group 9 and group 10 were cohesive. Overall, adhesive type failure was common amongst all groups. The present study was based on the hypothesis that LLLT in the form of ECL and NYL on conditioning of LDC and Y-TZP will exhibit comparable repair bond strength to conventional conditioning regimes. The laboratory-based study revealed that ECL and NYL conditioning of LDC and Y-TZP exhibited statistically lower shear bond strengths compared to conventional conditioning regimes HF acid+ salinization and AA. Therefore, the hypothesis was rejected. The quality and resilience of bond signifies clinical success of repaired ceramics. Mechanical and chemical roughening of LDC and YTZP is essential for obtaining a reliable bond. Recently, use of laser irradiation for surface roughening of ceramics in improving bond strength and adhesion of composite to resin has gained popularity (Alkhudhairy et al., 2019a; Vohra et al., 2019).

In the existing study, ECL application at wavelength of 2780nm, power 3.75W and 15Hz frequency was used, as ECL at these parameters are well absorbed by the dental tissues. Moreover, NYL was used at a wavelength of 1064nm as a conditioning strategy for LDC and YTZP. In the present study, YTZP and LDC surfaces treated with NYL (11.88 ± 1.98) (13.74 ± 1.54) and ECL (13.52 ± 2.68) (14.25 ± 2.24) exhibited comparable repair SBS scores. The findings of present study of low repair bond strength scores with NYL conditioning on YTZP corelates to the work done by (Akyil et al., 2010; Arami et al., 2014). A possible explanation to this outcome can be attributed to heat induction during laser irradiation causing damage to the superficial layer which gives weak attachment to underlying surface and composite resin resulting in repair bond failure (Akyil et al., 2010). Moreover, NYL exhibited low repair scores to LDC this finding was in harmony with study by Yucel et al., (2012). A potential clarification to this finding can be credited to laser parameters (frequency and power), nano crystalline structure of LDC (IPS Emax Press and IPS Empress 2), duration of laser irradiation and distance from the conditioning surface. Furthermore, low repair bond scores of ECL conditioning to LDC can be ascribed to high power output in the present study. This finding corelates to the study done by (Gökçe et al., 2007; Kirmali et al., 2015; Kursoglu et al., 2013).

The authors of the study suggest that with increase power SBS of ceramics decreases. It is expected that high power dislocates and causes irregularities of the crystalline structure of LDC compromising repair bond integrity. Moreover, ECL conditioning on YTZP showed increased repair bond strength to bur treated and NYL group but this was statistically insignificant. A study by Kirmali et al., (2015) investigated that ECL with sandblasting improved repair bond values. Moreover, work by Tokar et al., (2019) suggested ECL at short pulse duration displayed better repair bond integrity. In the present study ECL laser with long pulse duration was used which might ascribe to low bond integrity scores. Scanning electron microscopy (SEM) of the conditioned surface may give better justification to this outcome.

The highest repair bond strength was seen in LDC conditioned with HF acid and salinization. This finding was parallel to a study by (Ataol and Ergun, 2018; Colares et al., 2013). A possible justification to this outcome is that HF acid reaction with glass matrix forms hexa-flouro-silicates i.e., exposing and roughening the crystalline structure increasing the micromechanical retention. In addition, silanization after HF acid forms a chemical bond with composite resin improving repair bond integrity. AA conditioning on YTZP displayed the maximum repair bond scores. These finding are comparable to the work done by Akyil et al., (2010); Arami et al., (2014) and Kirmali et al., (2015). A probable description to these findings is that air abraded area using Al2O3 increases the surface roughness, develops undercuts this provides retention and facilitates silane coupling agent into these grooves enhancing repair bond strength.

Based on mode of failure and fracture analysis of specimen lased irradiated surface of both LDC and YTZP showed adhesive failure type. This finding was in correlation to low repair bond strength values. Moreover, AA conditioning and HF salinization on LDC and YTZP predominantly resulted in cohesive fracture. A possible explanation is the salinization process in AA and HF acid group resulting in cohesive failure type. A possible limitation of the present study was the absence of topographical analysis of the conditioned surfaces and energy dispersive spectrometry of the deboned specimens. Use of thermocycling procedures and conditions similar to oral cavity provided better understanding of short- and long-term durability of repair bond strength outcomes. Future studies should be directed in using different laser parameter along with other conditioning regimes with simulated ageing. Moreover, clinical trials with ex-vivo designs are recommended to validate the findings of this laboratory-based study.

Table 2. Modes of failure among different experimental groups

Failure type	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8	Group 9	Group 10
Adhesive	6	8	9	2	2	7	6	9	1	-
Cohesive	2	2	0	5	5	1	2	1	7	8
Admixed	2	0	1	3	3	2	2	1	2	2

CONCLUSION

HF acid with salinization remains gold standard for conditioning of LDC. AA with salinization is the most effective method to condition YTZP ceramics for better repair bond scores. Alternate methods of conditioning using laser (NYL and Er, Cr:YSGG) needs further investigation.

REFERENCES

Akyil, M.S., Uzun, I.H., Bayindir, F., (2010). Bond strength of resin cement to yttrium-stabilized tetragonal zirconia ceramic treated with air abrasion, silica coating, and laser irradiation. Photomed. Laser Surg. 28, 801–808.

Alkhudhairy, F., Alkheraif, A., Bin-Shuwaish, M., Al-Johany, S., Naseem, M., Vohra, F., (2018a). Effect of Er,Cr:YSGG laser and ascorbic acid on the bond strength and microleakage of bleached enamel surface. Photomed. Laser Surg. 36.

Alkhudhairy, F., Naseem, M., Ahmad, Z.H., Alnooh, A.N., Vohra, F., (2019a). Efficacy of phototherapy with different conventional surface treatments on adhesive quality of lithium disilicate ceramics. Photodiagnosis Photodyn. Ther. 25, 292–295.

Alkhudhairy, F., Naseem, M., Bin-Shuwaish, M., Vohra, F., (2018b). Efficacy of Er Cr: YSGG laser therapy at different frequency and power levels on bond integrity of composite to bleached enamel. Photodiagnosis Photodyn. Ther. 22.

Alkhudhairy, F., Vohra, F., Naseem, M., (2019b). Influence of Er,Cr:YSGG Laser Dentin Conditioning on the Bond Strength of Bioactive and Conventional Bulk-Fill Dental Restorative Material. Photobiomodulation, Photomedicine, Laser Surg.

Alkhudhairy, F., Vohra, F., Naseem, M., Ahmad, Z.H., (2019c). Adhesive bond integrity of dentin conditioned by photobiomodulation and bonded to bioactive restorative material. Photodiagnosis Photodyn. Ther. 28, 110–113.

Arami, S., Tabatabaei, M.H., Namdar, F., Safavi, N., Chiniforush, N., (2014). Shear bond strength of the repair composite resin to zirconia ceramic by different surface treatments. J. Lasers Med. Sci. 5, 171–175.

Ataol, A.S., Ergun, G., (2018). Effects of surface treatments on repair bond strength of a new CAD/CAM ZLS glass ceramic and two different types of CAD/CAM ceramics. J. Oral Sci. 60, 201–211.

Colares, R.C.R., Neri, J.R., de Souza, A.M.B., Pontes, K.M. de F., Mendonça, J.S., Santiago, S.L., (2013). Effect of surface pretreatments on the microtensile bond strength of lithium-disilicate ceramic repaired with composite resin. Braz. Dent. J. 24, 349–352.

Cristoforides, P., Amaral, R., May, L.G., Bottino, M.A., Valandro, L.F., (2012). Composite resin to yttria stabilized tetragonal zirconia polycrystal bonding: Comparison of repair methods. Oper. Dent. 37, 263–271.

Galvão Ribeiro, B.R., Galvão Rabelo Caldas, M.R., Almeida, A.A., Fonseca, R.G., Adabo, G.L., (2018). Effect of surface treatments on repair with composite resin of a partially monoclinic phase transformed yttrium-stabilized tetragonal zirconia. J. Prosthet. Dent. 119, 286–291.

Gökçe, B., Özpinar, B., Dündar, M., Çömlekoglu, E., Sen, B.H., Güngor, M.A., (2007). Bond strengths of all-ceramics: Acid vs laser etching. Oper. Dent. 32, 173–178.

Kirkpatrick, J.J.R., Enion, D.S., Burd, D.A.R., 1995. Hydrofluoric acid burns: a review. Burns.

Kirmali, O., Kapdan, A., Harorli, O.T., Barutcugil, C., Ozarslan, M.M., (2015). Efficacy of ceramic repair material on the bond strength of composite resin to zirconia ceramic. Acta Odontol. Scand. 73, 28–32.

Kursoglu, P., Motro, P.F.K., Yurdaguven, H., (2013). Shear bond strength of resin cement to an acid etched and a laser irradiated ceramic surface. J. Adv. Prosthodont. 5, 98–103.

Özcan, M., Valandro, L.F., Pereira, S.M.B., Amaral, R., Bottino, M.A., Pekkan, G., (2013). Effect of surface conditioning modalities on the repair bond strength of resin composite to the zirconia core / veneering ceramic complex. J. Adhes. Dent. 15, 207–210.

Tokar, E., Polat, S., Ozturk, C., (2019). Repair bond strength of composite to Er,Cr:YSGG laser irradiated zirconia and porcelain surfaces. Biomed. J. 42, 193–199.

Vohra, F., Labban, N., Al-Hussaini, A., Al-Jarboua, M., Zawawi, R., Alrahlah, A., Naseem, M., (2019). Influence of Er;Cr:YSGG Laser on Shear Bond Strength and Color Stability of Lithium Disilicate Ceramics: An in Vitro Study. Photobiomodulation, Photomedicine, Laser Surg. 37, 483–488.

Yucel, M.T., Aykent, F., Akman, S., Yondem, I., (2012). Effect of surface treatment methods on the shear bond strength between resin cement and all-ceramic core materials. J. Non. Cryst. Solids 358, 925–930.