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Effect of Thermal Aging on Shear Bond Strength Different Resin Cements to Zirconia

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Abstract: *The aim of this study was to investigate the effect of thermal cycling on different resin cement bond of zirconia ceramic.Sixtyzirconia discs with 3 mm thickness were prepared from zirconia blocks(Vita In-ceram YZ). Zirconia samples were sandblasted with Al_2O_3 powders having a particle size of 50 µm in the surface treatment for 60 sec under 2bar pressure and then silane application was performed on all samples. The samples were divided into two groups.A dual-cure adhesive resin cement Panavia V5 (Kuraray Dental, Tokyo, Japan) was cemented onto the first group specimensand RelyX Ultimate(3M Espe, Germany) resin cementwas applied onto the second specimens using cylindric molds with a diameter and high of 2 mm. Before thermal cycle, the specimens were stored in incubator at 37 ° C for 24 hours for completing polymerisation.Half of the samples of the two groups were not subjected to any aging process, while the remaining half were aged between 5-55 ° C temperature changes in the bath for 30 sec, transfer time 2 sec to 6000 rpm. Shear bond strengths were measured with a universal test machine(Shimadzu, Kyoto, Japan) and data were analyzed with a statistical programme (SPSS 24).There was no significant difference between the Panavia V5 and RelyX Ultimate groups before the thermal cyling ($p > 0.05$). There was a statistically significant difference between Panavia V5 and RelyX Ultimate after thermal cyling ($p<0.05$). Panavia V5 has a better bond strength before thermal aging, while the bonding strength is reduced with thermal aging by time.*

Keywords: *aging, resin cement, shear bond strength, thermal cycling, zirconia*

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I. Introduction

Many new materials have been developed as a result of the advancement of technology and aesthetics in today's dentistry. All ceramics were introduced to the market in order to meet aesthetic concerns and found widespread use. However, they provide good aesthetics but they do not have sufficient mechanical properties. Therefore, the use of chewing forces in areas where there is a high density or long toothless spaces is a problem.[1] This situation brought aesthetic aspects to the traditional ceramics and at the same time the mechanically superior zirconia ceramics.[2]

Zirconia ceramics are used as an endodontic post, implant base and a bar for the construction of anterior restorations in crown-bridge prostheses and aesthetics. Highly purified zirconium dioxide (zirconia) ceramics have become increasingly popular in clinical dentistry, particularly due to their superior mechanical properties such as high fracture resistance and fracture toughness in the posterior region.[3,4]

Some of the clinical failures associated with zirconia are related to the cementation procedures. In traditional ceramics, a successful resin cement bonding can be achieved by acidification and silane application, whereas in zirconia cementation both methods are not effective.[5] Zirconia ceramics are non-glass phase-free polycrystalline structure. For this reason, various methods have been developed to enhance the connection of the zirconia ceramics with resin cements, which offer good aesthetic and mechanical properties and are the best alternative to traditional ceramics.[6]

The blasting process with Al_2O_3 (aluminum oxide or alumina) is a highly preferred method for shaping the surface of high-resistant ceramics. In this method, Al_2O_3 particles with a size of 30-250 µm are sandblasted to remove the soft and contaminated layers on the surface and provide the required surface roughness for the micromechanical connection.[7,8]

If mechanical damage is being avoided, alternative techniques for forming a bond between the zirconia and the bonding system should be based on a chemical interaction. Various zirconia primers have been developed to provide chemically improved adhesion between resin cement and dental Yttria Stabilized Zirconia(Y-TZP).[5] They are easy to implement and do not need expensive and complex apparatuses. Nevertheless, controversial reports of hydrolytic stability have emerged and have shown that zirconia primers are not always a viable option.[9]

The technique of using multistage resin cement is time-consuming, complex so self etch/adhesiveresin cements has been developed. Despite the increases in the clinical use of self etch/adhesive resin cements, further evidence is needed for the adhesive cementation of Y-TZP restorations to create the most reliable technique. However, data on the shear resistance of adhesion to zirconia ceramics with newly developed zirconium primers and self etch/adhesive resin cements is not available.[10,11]

Restorations are exposed to temperature changes in the mouth. It is estimated that the temperature in the mouth ranges from 0 ° C to 60-65 ° C depending on the foods that are consumed. Thermal agings are commonly used to mimic the thermal stresses that occur in the oral environment, and this is based on the coefficients of thermal expansion of the materials.The aim of our study; to evaluate the connection of different cements on zirconia before and after thermal cycling.

II.Material and Methods

The ceramic samples used in the study were obtained using zirconia blocks(VITA In-Ceram YZ) measuring 20x15x14 mm.Zirconia blocks were cut to 3 mm thickness under water cooling using a special diamond disc (Isomet 1000; Buehler, USA) specific to zirconia ceramic in the sample cutting device set to 150 rpm rotation speed. 60 pieces of 3 mm thickness were obtained after cutting process.

The edges of samples were removed and samples were cleaned with ultrasonic device in distilled water at 40 kilohertz (kHz) for 5 minutes in the vibration was air dried.Sintered samples were placed into the center of the plastic moldswith a 25 mm diameter and 15 mm height and embedded in epoxy resin under vacuum in such a way that a surface of the porcelain was exposed by using a cold mounting device.

To ensure standardization on all surfaces prior to the application of the surface treatments, the surfaces of the ceramic samples were polished under water for 15 sec using a series of SiC abrasive discs (grains 120, 220, 600 and 1200) in an automatic polishing device with a rotation of 150 per minute.

Zircons were treated with Al_2O_3 powders having a particle size of 50 µmin the surface treatment for 60 sec under 2bar pressure and then silane application was performed on all samples.

The samples were divided into two groups. On the first group samples were cemented with Panavia V5 resin cement and Relyx Ultimate was cementedon the second group using plastic molds with 3mm diameter and 2 mm high.Before thermal aging, the samples were stored in incubator at 37 ° C for 24 hours. Half of the samples of the two groups were not subjected to any aging process, while the remaining half were aged between 5-55 ° C temperature changes in the bath for 30 sec, transfer time 2 sec to 6000 rpm. Measurement of the bonding strength of the samples was carried out using shear test.The universal tester applied a separation force of 0.5 mm per minute to the connecting interface. The force value when the composite was separated from the ceramic surface, was obtained in N unit, then the surface area in the break area was divided into 12.56 mm2 and converted to MPa and these values were recorded as bond strength values.SPSS 24(IBM, New York, USA)software program was used for statistical analysis.

III.Results

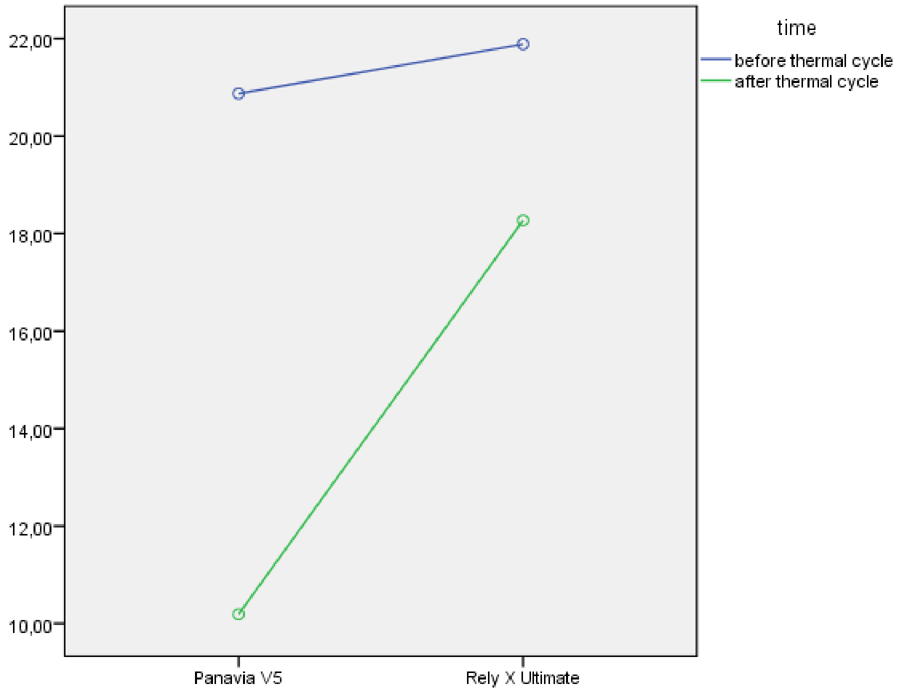
Table 1 shows the mean, standard deviation, maximum and minimum force values of the test groups, which are the result of static loading.(Table1)

Table 1. Descriptive Statistics Regarding Breaking Strengths by Groups

	Groups	Number of samples	Mean(Mpa)	St. deviation	Max (Mpa)	Min (Mpa)
Before thermal cycling	Panavia V5	10	22,87	7,57	29,53	14,73
	Relyx Ultimate	10	21,88	2,32	24,93	17,41
After thermal cycling	Panavia V5	10	12,19	4,50	19,00	4,53
	Relyx Ultimate	10	18,27	2,42	22,16	18

According to the one-way analysis of variance, there was no significant difference between the Panavia V5 and RelyX Ultimate group before the thermal aging ($p > 0.05$); There was a statistically significant difference between Panavia V5 and RelyX Ultimate after thermal aging ($p < 0.05$). The RelyX Ultimate group of the two cement groups after the thermal revving gave higher results.Statistically significant difference was found in Panavia V5 group before and after thermal revision. Figure 1 shows the shear test results of the groups graphically.

Figure 1. Descriptive Statistics Regarding Breaking Strengths by Groups



IV.Discussion

In this study, the resistance of two different resin cement with zirconia before and after artificial aging was investigated.

The increase in aesthetic expectation in dental restorations has increased the use of clinically full ceramic. The long-term functional, biological and aesthetic requirements of zirconium oxide-based restorations have increased the interest in this material.[15]

The roughening of the inner surface of the full ceramic restorations is a routine method. With 50µmAl_2O_3 and low pressure blasting, there was no clinical failure. In the studies, it has been concluded that the application of the zirconia ceramic surface to the blasting process prior to the cementation process significantly increases the bond strength of the composite resin cement to the ceramic surface. The sanding of the zirconia ceramic surface prior to cementation results in a mechanical roughening of the surface, thereby extending the cementation surface.[8,16] As a result, the adhesion of the adhesive to the surface increases, and in addition, the organic additives in the ceramic surface were also removed.Choosing the appropriate cement and bonding agent is important in achieving successful connection to zirconia. Zirconia based ceramics are opaque and chemical or dual-cure resin cements are preferred in their cementation. Dual-cure resin cements are both light and chemically polymerized and have the advantages of both systems.[17]

In the cementation of the dental restorations prepared with zirconia ceramics, the application of silane agent is considered to be a chemical bonding between the ceramic and composite resin cement after the surface is roughened and coated with silica.[18,19]After cementation, a strong bonding resistance was obtained between composite resin cement and zirconia ceramics. Because of this fact that the silica layer applied to the zirconia ceramic surface in order to apply the silane agent is not too tightly bonded to the surface and is removed from the zirconia ceramic surface in time. In artificial aging stage, water holding, thermal cycle and mechanical loading are generally applied before the test.[11]

Dental restorative materials are exposed to many effects in the mouth includeing temperature changes, humidity and mechanical factors. The artificial aging process, which is frequently used in the testing of dental resins and ceramics, allows the use of factors such as light and moisture. In our study, approximately 6 months of clinical effect was created by using 5000 aging device with artificial aging device. It is difficult to say that the artificial aging process we use in our study provides the same clinical conditions. Because, during the aging process, materials are only exposed to moisture, UV light and temperature variables. In addition, the aging device and the materials applied to dental materials such as moisture, temperature, UV light can be extremely high in terms of mouth conditions. However, it is difficult to evaluate the long term chemical changes of dental restorative materials with clinical studies. An artificial aging process in the laboratory can consideras an important method for researchers to standardize research on the properties of dental materials.

Shear test is widely used in laboratuary sincethe samples are prepared easily and quickly.[20] In addition, the chewing forces formed in the mouth are better imitated in the shear test.[21] Shear strength test was used in many studies evaluating the bond strength between ceramic material and resin cement.In our study, pre-and post-aging shear force was applied to zircon based resin composite samples and the values were obtained as Newton.

In zirconia-resin cement bonding studies it is seen that the resistance of post bonding after thermal aging decreases.[22,23,24] There are also studies in the literature where zirconia-resin cement bonding is separated during thermal aging.[24,25]

In our study, the effects of thermal cycling on bond strength values of adhesive cement systems were investigated. As a result of the study, the samples used with Panavia V5 have decreased dramatically with zirconium after thermal pumping. In the RelyX Ultimate group, while the connection was observed after thermal revving, this difference is much less than the Panavia V5 group.In this study, the effect of artificial aging on the connection of different resin cements to zirconium material is investigated.

Dental restorative materials are exposed to many effects in the mouth. These include temperature changes, humidity, mechanical factors. The artificial aging process, which is frequently used in the testing of dental resins and ceramics, allows the use of factors such as light and moisture. In our study, approximately 6 months of clinical effect was created by using 5000 aging device with artificial aging device.[26]In our study, pre-and post-aging shear force was applied to zircon based resin composite samples and the values were obtained as Newton.

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V.Conclusion

Studies have shown that the composition of the materials is responsible for the water absorption and water solubility of the material. Phosphoric acid groups, urethane dimethacrylate (UDMA), methacryloyloxydecyl-dihydrogenphosphate (MDP), hydroxymethacrylate (HEMA), such as hydrophilic monomer or filler cement-containing resin cements are stated to be more water absorption. Panavia V5 resin cement contains hydrophilic aliphatic dimethacrylate. This explains the water absorption of cement.

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