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ORIGINAL RESEARCH

Evaluation of the Effect of Cement Type on Retention of Fixed Zirconia Restoration

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Abstract

Background: Retention of the crown on teeth or abutment of the bridge is one of the important factors in the success of dental treatments, especially when teeth have a short crown. The aim of this study was to investigate the effect of cement type on fixed zirconia restorations.

Materials and Methods: In this experimental laboratory study, 60 samples were prepared in the form of a prepared tooth using a brass rod, with 11 mm length and 7 mm diameter in the margin and 6 mm in the upper part of the sample. The samples were used as an anti-rotation and then crowns of zirconia were designed and made by CAD/CAM on the samples. Then, 60 samples were randomly distributed into three equal groups and each group was cemented with one of three luting agents: glass ionomer, zinc phosphate, and panavia resin cement. The amount of force required to separate the crowns was measured by the universal testing machine. The data were analyzed by One-way ANOVA test and Tukey's post hoc test (α= 0.05).

Results: The mean dislodgement force required to remove fixed zirconia restorations differed significantly among the three cement groups (P < 0.001). The mean force in the zinc phosphate cement group was significantly higher than that in the Panavia resin cement group (P = 0.001) .The mean force in the Panavia group was significantly higher than that in the glass ionomer cement group (P < 0.001).

Conclusion: The use of zinc phosphate cement in comparison to Panavia and glass ionomer provides more retention for zirconia crowns.

Keyword: Cement; Retention; Zirconium

Introduction

The placement of fixed prostheses for replacing missing teeth improves patient comfort and chewing ability. Fixed prostheses include crowns and bridges. A crown is placed over a prepared tooth, and a bridge is placed on adjacent abutment teeth and includes the replaced teeth as well (1,2).

The retention strength of the crown on the tooth or bridge abutment is one of the important factors in the success of dental treatments, especially when the teeth have short crowns. Retention is influenced by a set of factors that encompass everything from the initiation of tooth preparation to the final stage of cementation and must be considered. Even if one factor is overlooked, it can affect the prosthesis retention, which ultimately has a direct impact on the longevity of the prosthetic treatment. One of the factors affecting crown retention is the cement and its relationship with the core material (3). An ideal cement should have good mechanical properties to resist functional forces, adhere well to the underlying crown, and have high stress-bearing capacity. In addition to the cement, the type of core material and the physical and chemical relationship between the luting cement and the core material are also of great importance (4).

The method of cementing a crown can potentially have a negative impact on the complete seating of the

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crown, appropriate proximal contacts after cementation, as well as reduce crown retention and it can cause margin opening (5,6). Various materials are used in the fabrication of crowns; tooth-colored restorations have long been of great interest for aesthetic reasons. In recent years, zirconia has been widely used in dentistry; its applications include inlays, onlays, coping crowns, fixed prosthesis frameworks, implants, and zirconia abutments (1).

The attractive properties of zirconium oxide, such as high strength, excellent mechanical properties, and biocompatibility, have led to various applications in dentistry, including as a primary material in all-ceramic crowns and fixed partial dentures. The mechanical properties of zirconia are superior to all other ceramics; it is the only ceramic that can be used as a framework for multi-unit fixed prostheses, even in the posterior region of the mouth (7). The sealing ability of a cement plays a very important role in maintaining the health of the dental pulp. The bonding or cementation site must be free of microleakage to protect the tooth structure from damage caused by the penetration of fluids and microorganisms.

For a restoration to function over a long period, it is crucial to pay attention to the adhesion between the hybrid layer formed on the pulp-dentin complex surface and the resin cement, as well as between the zirconia restoration and the resin cement (8). In the study performed by Alves et al. (9), the type of cement did not affect retention, whereas the surface preparation of the zirconia ceramic did affect the retention.

Given the limited number of studies on the effect of different cements on the bond strength and retention of zirconium oxide crowns on prepared tooth crowns (10), and considering the increasing use of restorations made by the CAD/CAM method and the lack of studies on the effect of different cements on their retention, the aim of this study was to investigate the effect of glass ionomer cement, zinc phosphate cement, and Panavia resin cement on the retention of fixed zirconia restorations.

Materials and Methods

In this experimental laboratory study, 60 specimens resembling prepared teeth were fabricated using brass rods (Brand). Each specimen had a length of 11 millimeters, a diameter of 7 millimeters at the margin edge, and 6 millimeters at the top. These specimens were prepared with a 6-degree convergence angle and a chamfer margin at a 135-degree angle. A V-shaped groove, 2 millimeters wide, was placed below the finish line, and an anti-rotation notch measuring 1 × 3 millimeters was created at the top of the specimens (Figure 1).

Figure 1. Brass die sample.

To prepare the zirconia crowns, the brass specimens were washed with alcohol and then divided into three groups of 20. The specimens in groups 1,2, and 3 were respectively numbered from A1 to A20, B1 to B20, and C1 to C20. The design was carried out by computer (Figure 2). After designing, the crowns were milled from zirconia blanks (IPS E.max ZirCAD, Ivoclar, Schaan, Liechtenstein) using a milling machine (Amann Girrbach, Germany) and then placed in a sintering furnace (Programat S2, Ivoclar, Schaan, Liechtenstein) at 900 degrees Celsius for 12 hours. The seating of the crowns on the specimens was evaluated.

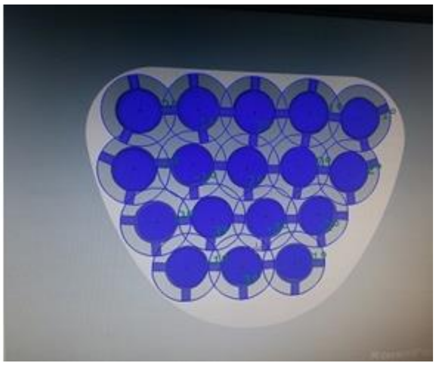

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Figure 2. Computer-aided design.

For cementing the crowns onto the brass specimens, the specimens were divided into three groups of 20. The first group was cemented with glass ionomer cement (GC Corporation, Tokyo, Japan), the second group with zinc phosphate cement (Hoffmann Dental, Berlin, Germany), and the third group with Panavia resin cement (Kuraray, Osaka, Japan), following the manufacturer's recommended procedures.

The specimens with the crowns were then placed in an electromechanical universal testing machine (K-21046, Walter + Bai, Switzerland) designed to standardize the application of force and subjected to a static force of 5 kilograms for 10 minutes until final setting; excess cement was removed. After cementation, the specimens were placed in a universal testing machine (Santam Co., Tehran, Iran) and subjected to tensile force at a rate of 0.5 millimeters per minute. Each sample was fixed in the base part of the machine, and the coating was subjected to a tensile force of 0.5 mm/min by a special clip and a hook whose end was connected to the machine (Figure 3).

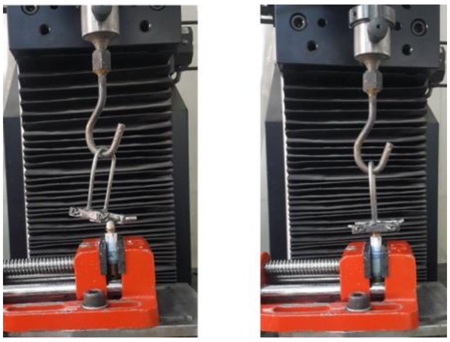

Figure 3. Universal test machine.

The Kolmogorov-Smirnov test showed that the number of fixed zirconium restorations in all three groups followed a normal distribution. The amount of crown retention was measured by the universal testing machine in Newtons; the force required to dislodge each crown was recorded. The obtained data were analyzed using SPSS software version 20 (IBM, SPSS Inc., U.S.A.), one-way ANOVA, and Tukey's post-hoc tests, considering a significance level of 0.05.

Results

According to the results of the ANOVA test, the mean retention of fixed zirconia restorations among the three groups showed a significant difference ($P < 0.001$). In Pairwise comparison between the groups based on Tukey's test, the mean retention in the zinc phosphate cement group was significantly higher than that in the Panavia resin cement group ($P = 0.001$), and the mean retention in the Panavia resin cement group was significantly higher than that in the glass ionomer cement group ($P < 0.001$) (Table 1).

Table 1. Mean Retention of Fixed Zirconia Restorations in Three Groups (in Newtons)

Group	Mean ± SD	P value
Glass Ionomer Cement	363.9 ±104.5	
Zinc Phosphate Cement	1250.3 ±406.9	< 0.001
Panavia Resin Cement	940.4 ±163.6	

Discussion

In evaluating the retention of fixed zirconia crowns cemented with three types of cements—glass ionomer, zinc phosphate, and Panavia resin cement—the results showed that the use of zinc phosphate cement provided greater retention strength for zirconia crowns compared to Panavia and glass ionomer.

Since natural teeth vary according to age and inherent characteristics, and storage time also affects crown retention, standardization and uniformity of samples become difficult. In some studies, metal or resin models have been used to measure retention. The advantages of metal dies include easy repeated production, fewer variables, standard preparation, minimal wear during the fabrication and measurement processes, and sample strength. Therefore, in this study, to standardize and unify the samples, machined brass dies were used instead of natural teeth (11,12).

The luting material should have appropriate consistency and, consequently, sufficient flow to allow the restoration to be easily seated on the tooth. If the consistency of the luting cement is too high, the cement becomes thick, and the restoration does not seat properly. Because its thickness increases, the likelihood of cement dissolution in the oral environment will increase, which will, in turn, affect the bond strength and crown retention. For this purpose, an appropriate consistency was used for cementation in this study (13).

The film thickness for zinc phosphate as a luting agent is 25 microns. Because the consistency of the mixture increases rapidly, the casting should be seated immediately after mixing; otherwise, seating the restoration becomes difficult. In the study by Opler et al. (14), examining three cementation

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methods—including completely filling the crown with cement, placing cement on the margin edges, and coating the crown walls with cement on crowns made on implants—they concluded that excessive cement volume prevents crown seating, and insufficient cement volume leads to inadequate retention and marginal leakage. Among these three cementation methods, placing cement on the margin edge and coating the crown walls with cement using a brush resulted in better crown seating and, consequently, increased retention. Therefore, in this study, the method of coating the crown walls was used to achieve better vertical seating of the crowns (15).

In the study by Musajo et al. (16), which examined the role of convergence angle and type of cement on crown retention, it was determined that the degree of convergence is more effective than the type of cement. Additionally, air entrapment plays a significant role in crown dislodgement; therefore, in the present study, brass specimens with a convergence angle of 6 degrees were used.

Different studies investigating the effect of cement on the retention of fabricated restorations have yielded varying results. For instance, when non-adhesive cements like zinc phosphate are used, retention depends on the preparation form (i.e., less convergence in tooth preparation), because this cement does not chemically bond to the tooth structure. Instead, mechanical retention exists at the contact surface (17).

Despite the mechanical advantages of zirconia, its disadvantages include weak bonding to various substrates, whether synthetic or biological tissues. Due to the inert nature of this material, conventional cementation and bonding methods for zirconia structures do not provide sufficient bond strength for many clinical applications. Additionally, because of its inert and non-polar surface, zirconia has a low chemical bonding capability. Zirconia-based restorations cannot be etched with hydrofluoric acid due to the absence of a glassy matrix, and since they do not contain silica, silane agents have no effect on them. To enhance adhesion to this material, the restoration must be sandblasted before cementation (18,19).

Resin cements have low solubility and establish a micromechanical bond to prepared enamel, dentin, alloys, and ceramics. Glass ionomer forms a physical-chemical bond to the tooth. Since brass dies were used in this study, glass ionomer could not bond to the metal, and the zirconia surface also has weak bonding capability. This factor may explain the lower retention of glass ionomer compared to Panavia (20).

In examining the effect of three types of cements—resin-modified glass ionomer cement, self-adhesive resin cement, and adhesive resin cement—on the bond strength of zirconia copings to crowns fabricated under laboratory conditions by Khalil Aleisa et al. (10), no significant difference was found among these three cements. In Khalil Aleisa's study, finger pressure was applied for 5 minutes during cementation, which might have caused deviations in the obtained results. In contrast, in the present study, to standardize and unify the application of force, a pressure device was used, and the samples were subjected to a static force of 5 kilograms for 10 minutes.

In previous studies assessing the shear bond strength of different cements in contact with various prosthetic crowns, including zirconia, resin-based cements exhibited higher shear bond strength compared to resin-modified glass ionomer cement, which aligns with the results of the present study (21,22).

One of the issues with metal dies is their smooth metallic surface, which differs from clinical conditions. Studies have shown that glass ionomer does not bond to inert surfaces. Additionally, glass ionomer has higher solubility than other cements and is highly sensitive to early contact with water and drying, which can significantly reduce the mechanical properties of the cement. In the present study, no surface preparation was performed on the crowns and dies, which could be a reason for the lower retention of glass ionomer cement compared to zinc phosphate and Panavia (23). In the review study by Maroulakos et al. (24), zirconia and lithium disilicate tooth-supported crowns exhibited comparable survival rates and complication patterns after adhesive or conventional cementation.

Zidan and Ferguson (25), in comparing the retention of crowns with different types of cements and degrees of taper, showed that the retention values achieved by resin cements are twice those of zinc phosphate and glass ionomer. Failure in retention depends on the degree of convergence of the preparation and the type of cement used. A high convergence angle (24 degrees) results in the least retention, which contrasts with the results of the present study. This difference could be due to the

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varying number of samples and the type of samples used (natural teeth versus brass dies).

Bond strength to ceramics is influenced by the polymerization method of the resin cement (visible light, dual-cure, auto polymerization), thermocycling, water storage, and the cement itself. Long-term water storage and thermocycling are conditions often used to assess the durability of cements. Some studies have shown that water plays a significant role in the degradation of the bond between resin cement and zirconia ceramics. In the present study, thermocycling was not performed, which may have affected the results (10).

The study conducted by Dähne et al. (26) revealed that artificial aging significantly influences retention forces, simulating clinical conditions. Under the selected test conditions, implantlink semi-Forte (IMP) exhibited the highest pull-off forces. All three temporary luting agents demonstrated notably lower retention forces after undergoing thermocycling. Due to the ease of cement removal from the crown lumen, the prevalence of adhesive cement fractures on the abutment, along with adhesive or cohesive cement fractures involving Harvard Implant Semi-permanent (HAV), can be advantageous for recementing the superstructure. This information provides clinicians with guidance on which cement to use based on different requirements. The differences between the results of this study and previous studies are due to variations in measurement methods, different measuring devices (universal testing machines), materials, and the precision in their fabrication. In any case, given that this study was laboratory research, it cannot replicate the viscosity of the periodontal ligament and the natural compressibility of the crown. These factors may affect the final seating of the crown and its retention.

Although our study found that zinc phosphate cement provided greater retention for zirconia crowns than Panavia resin cement, other clinical studies have demonstrated excellent performance of resin cements. For instance, a retrospective study reported a 100% survival rate over five years for zirconia crowns cemented with two different self-adhesive resin cements, including Panavia SA, with no loss of retention observed, highlighting the effectiveness of resin cements in clinical practice (27). Conversely, a 36-month randomized clinical trial on prefabricated zirconia crowns in primary molars found that crowns cemented with traditional glass ionomer cement exhibited superior retention compared to resin-based cements, suggesting that the choice of cement may have different implications depending on the clinical scenario and crown type (28).

Furthermore, research evaluating the effect of cement type on the fracture load of zirconia crowns indicated that the use of adhesive resin cement significantly enhanced fracture resistance, especially in preparations with minimal axial wall height, emphasizing the role of cement selection in the mechanical performance of zirconia restorations (29). Additionally, a study comparing different primer-cement systems found that the retention strength of zirconia crowns was improved when using specific resin cement systems, such as Panavia V5 with Clearfil Ceramic Primer Plus, supporting the notion that resin cements can provide high retention strength for zirconia crowns when used with appropriate primers (30).

Conclusion

Zinc phosphate cement, compared to Panavia and glass ionomer, showed greater retention strength for zirconia crowns.

Conflict of Interests: The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial, or non-financial in this article

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