

Luting Agent Effectiveness on Implant Crown Retention

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ABSTRACT

Statement of problem: Due to the conflicting results in literature, it is not clear which luting agent is suitable for implant retained fixed restorations in different clinical situations.

Purpose: The purpose of this study was to compare the retention of single crowns on implant direct abutments cemented with different conventional luting agents.

Materials and methods: The study included 98 single crowns cemented with seven luting agents on to the abutments. Sandblasting was used as surface treatment. After cementation thermocycling was applied. The uniaxial tensile force was applied to all test crowns using universal test machine (Instron) at 0.5 mm/min. The load required to dislodge each crown was recorded in Newton. Means and standart deviations of loads at failure were analyzed using ANOVA. Statistical significance was set at ($p < 0.05$).

Results: There were statistically significant differences among the groups for each luting agents ($p < 0.05$). Using adhesive resins (Panavia F 2.0) showed higher bond strength values in both sandblasted and nonblasted groups. The weakest bond strength values were obtained by using temporary luting agent (Cavex temporary cement).

Conclusions: Within limitations of this study it can be said that when strong retention is necessary for implant-retained prosthesis, adhesive resin system is more retentive than zinc phosphate and zinc polycarboxylate. If the restoration needs retrievability, noneugenol temporary luting agent can be offered.

Clinical Implications: Retentiveness of implant-retained fixed restorations is related not only to surface characteristics of abutment and crown but also to luting agents.

Keywords: Abutment, Retention, Cementation, Fixed restoration, Luting agent.

INTRODUCTION

Today implant systems present good long-term success levels with several advantages over the traditional fixed and removable treatments. Implant abutments have two different restoration choices like screw-retained and cement-retained. One of the advantages of screw-retained restorations over cement-retained restorations is retrievability.

In a cement-retained implant restoration, when abutment preparation is necessary, the abutment's preparation design, height surface and roughness affect the retention of the restoration. In these different situations, selection of the luting agent type is important for the success of implant integrity and retention.¹⁻⁶ No single retrievable luting agent is sufficient for all clinical situations (such as resistance, retention form, number of abutments and distribution, accuracy of superstructure fit).^{4,7-13} Ideally, the luting agent should be strong enough to retain the restorations, yet weak enough so that restorations can be removed easily if required.

When the literatures are evaluated, it seemed that there are limited studies and conflicting results on the retention of implant crowns to abutments.

The purpose of this study was to compare the tensile bond strength of single crowns on metal abutments cemented with different luting agents before or after surface treatments.

MATERIALS AND METHODS

In the present study, the commonly used and commercially available seven types of dental luting agents were evaluated. The luting agents used in this study are shown in Table 1. A total of 28 screw plant implants (Implant Direct Systems, Calabasas, CA, USA) and their abutments (5.0 mm in height and 3.7 mm in diameter) were used in the study. Ninety eight base metal alloy single crowns were casted (Wiron 99, Bego, Bremen, Germany) and randomly divided into two groups. Half of the castings were sandblasted and the others were used as control.

Each implant was mounted in a 1-inch diameter self-polymerizing acrylic resin block (Repair Material, Dentsply International, Milford, DE, USA) using a dental surveyor. Abutments were placed on each implant and torqued to 35 Ncm. The abutment's screw was covered with a cotton pellet and the access hole was closed with cavite (3M ESPE, St Paul, MN). Ninety eight crowns were fabricated with the

Table 1

Luting agents listed by name, type and manufacturer

<i>Cement name</i>	<i>Cement type</i>	<i>Manufacturer</i>
Adhesor	Zinc phosphate	Spofa Dental, Markova, CK
Adhesor Carbofine	Zinc polycarboxylate	Spofa Dental, Markova, CK
Cavex Temporary	Noneugenol temporary	Cavex, Holland, BV
Dycal Dentin	Radiopaque calcium hydroxide composition	Dentsply, Milford, DE
Meron	Universal resin reinforced glass ionomer	VOCO, Cuxhaven, Germany
Panavia F 2.0	Dual cure dental adhesive system	Kuraray Dental, NY, USA
Premier	Noneugenol temporary resin implant luting agent	Premier Products Company, PA, USA

following method: Snap on comfort caps with 5.0 mm in height were adapted on each abutment and waxed¹ (Fig. 1). A loop of wax was added to the occlusal surface of the coping to allow for subsequent retention testing.^{14,15} All the plastic copings were invested and cast in a base metal alloy conventionally (Fig. 2). Castings were adapted to the abutments using disclosing wax to achieve the passive fit. Steam was used for cleaning wax from the castings. For sandblasting half of the crowns' internal surfaces were airborne-particle abraded using 50 µm aluminum oxide at 50 psi at 10 mm distance (Korox 50, Bego, Bremen, Germany). Sandblasted crowns' internal surfaces were steam cleaned again. The luting agents were mixed following the manufacturer's instructions. The test crowns were cemented to abutments using a uniform 2 kg load and placed in a humidior at 37°C for 24 hours. After 24 hours, thermocycling was applied to simulate oral environment. Cemented samples were thermocycled for 1000 times in water baths between the temperatures of $5 \pm 2^\circ\text{C}$ and $55 \pm 2^\circ\text{C}$ with a dwell time of 30 ± 2 second in each bath. The uniaxial tensile force was applied to all test crowns using universal test machine (Instron, Lloyd LRX, Fareham, England) with a crosshead speed of 0.5 mm/min until cement failure occurred (Fig. 3). The load required to dislodge each crown was recorded in Newton. After the crowns were dislodged from the abutments, the abutments were placed into the ultrasonic unit using cement removal solution for 20 minutes then rinsed and placed again in distilled water for 5 minutes. The other non-used crowns were cemented with the same procedure (Table 2).

The normality assumptions were controlled by Kolmogorov-Smirnov test ($p > 0.05$). The data were normally distributed therefore parametric statistics were used to evaluate the data. Two-way ANOVA and Post-Hoc Tukey test were used for pairwise comparison at a confidence interval of 95%. All statistical analyzes were carried out using SPSS software version 13.0 (SPSS, Chicago, IL, USA). The mean values and standart deviations were used

**Fig. 1:** Snap on comfort cap on the abutment**Fig. 2:** Casted crown on the abutment**Fig. 3:** Cemented crown on universal test machine before tensile test

as the descriptive statistics. Statistical significance was set at $p \leq 0.05$.

RESULTS

Retention values are shown in Table 2. Using adhesive resins (Panavia F 2.0) showed higher bond strength values in both sandblasted (517.7 ± 3.1) and nonblasted (480.1 ± 5.8) groups. Sandblasting increased the retentive values of luting agents significantly. The weakest bond strength values were obtained, by using temporary luting agent (Cavex Temporary Cement). The retentive values of sandblasted (424 ± 18) and nonblasted (380 ± 13) crowns were cemented with zinc polycarboxylate luting agent followed the adhesive resin, and there was statistically significant difference between the two groups. The retentive values of calcium hydroxide and resin reinforced glass ionomer were approximately similar to each other in both sandblasted and nonblasted groups $p > 0.05$. The retentive values of all luting agents were different significantly from each other except the two luting agents mentioned above $p < 0.05$.

DISCUSSION

Luting agents tested in this study ranged from common dental luting agents generally designated for permanent cementation to those considered for provisional cementation.

Generally bond strength of luting agents designed for cementation of crowns and bridges to teeth structures are stronger than titanium abutments, which have no caries and undercuts.¹⁶ Because of this phenomania for cementation of implant retained prosthesis, stronger luting agent should be selected than the one used for the teeth.

In the study, as expected, crowns cemented with adhesive resin showed the highest retention values between all groups. Panavia F 2.0 contains MDP monomer (10-Methacryloxydecyl dihydrogen phosphate), which can react chemically

with chromium oxide created on the casting surface. The strong bonding between crown and abutment is created by micromechanical retention promoted by sandblasting and the layer of chromium oxides easily created on the casting metal surface.¹⁷

The mean bond strength provided by zinc polycarboxylate was significantly greater than the other luting agents except adhesive resin. The adhesive properties of zinc polycarboxylate proved that during setting, this type of luting agent can adhere to tooth structure by chelation of calcium ions¹⁷ and to metal substrates by chelation of metallic ions.¹⁸⁻²¹

In contrast to the results of some studies, one finding of this study was that zinc phosphate showed weak bond strength than zinc polycarboxylate and adhesive resin.^{22,23}

According to the result of this study, resin-based provisional luting agent (Premier) provided higher tensile strength than zinc oxide based (Cavex Temporary) provisional luting agent.

Kim et al⁴ reported that the interaction between a provisional luting agent and surface treatment of an abutment is important for retention. As observed in the present study, the effect of luting agents on tensile strength differs depending on the surface treatment.

The recent study was focused on the study that some authors had found resin and glass ionomer-based luting agents to be the most retentive²⁴⁻²⁸ while others found zinc phosphate.^{22,23} Akça et al,²⁹ Mansour et al³⁰ and Sheets et al³¹ stated that polycarboxylate had higher retentive strengths than glass ionomer, zinc phosphate and provisional luting agents.

In the study of Squier et al³² they compared the retentive strengths of different luting agents used to cement noble metal alloy crowns to ITI implant abutments. Although they evaluated the bond strength between noble metal alloy

Table 2

Mean tensile bond strength values and standart deviations for all luting agents

Luting agent	Surface treatment	Number	Mean \pm SD (Newtons)	Diff*
Adhesor	Control	7	291.0 \pm 13.6	–
	Sandblasting	7	317.0 \pm 11.0	–
Adhesor Carbofine	Control	7	380.7 \pm 13.7	–
	Sandblasting	7	424.4 \pm 18.1	–
Cavex Temporary	Control	7	117.3 \pm 4.8	–
	Sandblasting	7	141.4 \pm 4.0	–
Dycal Dentin	Control	7	236.1 \pm 13.0	a
	Sandblasting	7	258.6 \pm 8.2	bc
Meron Plus	Control	7	253.0 \pm 10.3	ab
	Sandblasting	7	275.6 \pm 9.0	c
Panavia F 2.0	Control	7	480.1 \pm 5.8	–
	Sandblasting	7	517.7 \pm 3.1	–
Premier	Control	7	203.4 \pm 3.8	–
	Sandblasting	7	233.4 \pm 4.2	–

*Values having same letters were not significantly different for Post-Hoc Tukey test $p > 0.05$.

crowns to titanium abutments, the mean bond strength values of the luting agents were in accordance with this study.

In the study of Sheets et al they compared the retentive strengths of different luting agents used to cement base metal alloy crowns to ITI implant abutments.³¹ This time provisional luting agents were used for crown retention test. In their study, premier luting agent's mean bond strength value was close to this study's result.

Mansour et al tested the retention of metal copings fabricated to fit on ITI abutment using six different luting agents.³⁰ In their study, the mean bond strength values for the luting agents showed almost the same results with this study. In this study, resin luting agent showed significantly highest bond strength and the temporary luting agent showed the lowest bond strength.

Sadig et al¹ compared the effect of different surface conditions on the retentiveness of titanium crowns cemented over short ITI abutments using zinc polycarboxylate and adhesive resin. In their study, the highest retentive value was obtained with sandblasted casting and sandblasted abutment, pretreated with alloy primer and luted with Panavia 21. Although they have evaluated titanium crowns for the two types of luting agents, the results of the Sadig et al's study are in accordance with this study.

In the study of Mansour et al³⁰ it is also observed that luting agent retentiveness always occurred at the luting agent—abutment interface. Since, the residual luting agent was generally present inside the casting in the present study, 140 crowns were casted, and in each cementation, a new crown was used to prevent the lack of crown retention.

Hebel and Gajjar⁶ reported that temporary luting agent mixed with petroleum jelly provided adequate retention for fixed partial dentures when multiple abutments are splinted. However in the study of Sheets et al³¹ and Bernal et al,³³ the retentive values for temporary luting agent and petroleum jelly were described as very low. Many authors concluded that zinc eugenol may be more appropriate for the cementation of implant supported fixed dentures when retrievability is important.

When luting agents were not compared among themselves, bond strength values were statistically different between sandblasted and control groups. According to our knowledge, surface treatments could have increased luting agent abutment micromechanical interlocking leading to increased luting agent retention value. Treatment with different chemical components, such as tin plating and silicoating are not commonly used methods to increase bonding because of their requirement of additional equipments⁶ and for their cost. In the limitations of this study, only sandblasting was evaluated and abutment surfaces were not modified with any preparation. According to the results of the study, we think that sandblasting is sufficient for micromechanical interlocking between abutment and casting when a strong bond is required. Further studies may be required to determine the influence of

different aluminium oxide particle size and different surface treatments in both abutment and casting surfaces in implant supported fixed prosthesis.

In many studies related with the retention of implant supported fixed prosthesis, using different abutment types, heights and diameters, abutment preparation, surface roughness and treatments and also applying thermocycling may differ the results of the studies.

As a result, there are still so many researches about the implant crown retention. In a survey study, which was made in the United States, dental schools for cementation protocols of implant crown restorations, the most commonly taught luting agent for definitive cementation has been reported to be resin-modified glass ionomer followed by zinc oxide eugenol-based cement, glass ionomer, resin, zinc phosphate, and polycarboxylate cement.²⁴

According to the ISO TR 11450, thermocycling 500 times in water at temperatures between 5 and 55°C is considered to be an appropriate test for aging dental materials.³⁴ In this study, thermocycling was applied 1000 times in water baths to simulate oral environment.

The Implant Direct System is a common trademark in dental implantology. The system's abutment and snap on comfort cap has a retentive groove that provides retention, eliminates crown rotation and serves as a guide on crown adjustment. In the present study, this system was selected because there are no *in vitro* or clinical studies in the literature to date that evaluate retentiveness of Implant Direct System prosthetic components.

Since the retention values associated with implant direct system abutments have not been reported in the literature, in the present study, the effects of the surface treatment and also the luting agents were evaluated for their effectiveness on the retention of the crowns by means of tensile testing.

CONCLUSION

Within the limitations of this *in vitro* study, following conclusions were drawn:

1. Adhesive resin was the most retentive luting agent followed by zinc polycarboxylate and zinc phosphate for both sandblasted and control groups of crowns cemented on to the implant abutments.
2. Sandblasting is sufficient for micromechanical interlocking between implant abutment and crown.
3. When restoration needs retrievability, non eugenol temporary luting agent can be offered.

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