

Effect of Abutment Modification and Cement Type on Retention of Cement-Retained Implant Supported Crowns

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Abstract

Objective: Provisional cements are commonly used to facilitate retrievability of cement-retained fixed implant restorations; but compromised abutment preparation may affect the retention of implant-retained crowns. The purpose of this study was to investigate the effect of abutment design and type of luting agent on the retentive strength of cement-retained implant restorations.

Material and Methods: Two prefabricated abutments were attached to their corresponding analogs and embedded in an acrylic resin block. The first abutment (control group) was left intact without any modifications. The screw access channel for the first abutment was completely filled with composite resin. In the second abutment, (test group) the axial wall was partially removed to form an abutment with 3 walls. Wax models were made by CAD/CAM. Ten cast copings were fabricated for each abutment. The prepared copings were cemented on the abutments by Temp Bond luting agent under standardized conditions (n=20). The assemblies were stored in 100% humidity for one day at 37°C prior to testing. The cast crown was removed from the abutment using an Instron machine, and the peak removal force was recorded.

Coping/abutment specimens were cleaned after testing, and the testing procedure was repeated for Dycal luting agent (n=20). Data were analyzed with two-way ANOVA ($\alpha=0.05$).

Results: There was no significant difference in the mean transformed retention (Ln-R) between intact abutments (4.90 ± 0.37) and the abutments with 3 walls (4.83 ± 0.25) using Dycal luting agent. However, in TempBond group, the mean transformed retention (Ln-R) was significantly lower in the intact abutment (3.9 ± 0.23) compared to the abutment with 3 walls (4.13 ± 0.33 , $P=0.027$).

Conclusion: The retention of cement-retained implant restoration can be improved by the type of temporary cement used. The retention of cast crowns cemented to implant abutments with TempBond is influenced by the wall removal.

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INTRODUCTION

The success of oral rehabilitation in patients undergoing implant therapy depends not only on the osseointegration of the implant fixture

but also on maintaining the integrity of the connection between the prosthetic superstructure and the fixture [1]. Implant restorations can be screw-retained, cement-retained, or a

combination of both; each having its own advantages and disadvantages [2].

A cemented restoration has several advantages for use as a fixed implant prosthesis such as passive cast, equal stress distribution, enhanced esthetics, lower cost and being less time-consuming [3].

In screw-retained designs, loosening or breakage of the screws may necessitate the repair or replacement of the prosthesis. In cement-retained designs, luting agent bond failure at the prosthesis-implant abutment, or abutment-fixture interface can also result in prosthesis failure [4].

In implant systems where the abutments are cemented to the super structure, the provisional luting agent used must be strong enough to resist functional loads, but weak enough to allow removal of the superstructure with no harm to the abutment, implant fixture or the peri-implant tissue [4, 5]. A provisional luting agent may also be used as a final luting agent when the superstructure is entirely implant-supported or when natural tooth abutments are protected by a cast metal coping cemented with a permanent luting agent [4].

When a provisionally cemented superstructure needs to be removed from a cemented abutment, the retentive strength of the luting agent at the abutment/fixture and superstructure/abutment interface is a major concern.

The choice of cement for an implant-supported restoration should be based on the need or desire for retrievability, the anticipated amount of retention needed, the ease of cement removal, and cost [6-8].

Abutment surface preparation, and the abutment taper, width, and height also affect the retentive strength of cement-retained implant-supported restorations [9].

Temporary cementation may be more suitable for restorations supported by multiple implants [10].

Ideal taper and long walls of implant abutment favor the use of provisional cements. Nevertheless, not enough evidence is available on

the most suitable type of cement or the behavior of provisional cements over time [11, 12]. The purpose of this study was to investigate the effect of abutment design and type of provisional luting agent on the retentive strength of cement-retained implant restorations. The null hypothesis was that there would be no significant difference in the retention of cemented crowns on intact implant abutments or those that have lost one wall without engaging the screw access channel.

MATERIALS AND METHODS

Two prefabricated straight abutments (D10, SM, Korea) were attached to two corresponding implant analogs. The implant-abutment interface diameter was 4.1mm for all. The height of the selected abutments was 5.5mm; the butment-analog complexes were vertically mounted into individual acrylic resin blocks (Acropars 200, Marlic Medical Industries Co. Tehran, Iran). The vertical location of the implant analogs in the resin blocks was verified with a dental surveyor (Ney Dental Intl, Bloomfield, Conn).

The acrylic resin surface was 1 mm short of the implant-abutment joint. The abutments were connected to the implant analogs and were torqued to 35Ncm.

The first abutment was left intact without any modification. The other abutment was prepared by using a tapered carbide bur to remove 4mm of the height of one wall. For the first abutment, a cotton pellet was placed over the abutment screw and the screw access channel was completely filled with composite resin (PRIME-DENT, Chemical cure, USA). For the second abutment a cotton pellet was placed over the abutment screw access channel and the removed wall region was kept open. Twenty wax copings (Laserdenta-CAD WAXGOLD, Germany) were fabricated directly on the first abutment by CAD/CAM technique using 3Shape D810 scanner (Denmark) and CAD/CAM machine (imes-icore, GmbH, Germany).



Fig 1. Mounting of implant analog and abutment into acrylic resin with castings constructed in two groups

Two layers of die spacer (Tru-fit, Jersey City, NJ) were painted over the abutment with 2mm distance from the margin.

A loop attachment was added to the occlusal surface of each coping before casting. Wax copings were sprued, invested with phosphate-bonded investment material (ERNST HINRICHS GmbH, Germany) and cast with base metal alloy (4all, Ivoclar, Vivadent, Liechtenstein).

Twenty wax copings were fabricated on the second abutment by the same technique (Figure 1). Castings were inspected for surface irregularities. Positive internal irregularities were removed with a No. ½ round bur (SS white, Lakewood, New jersey, USA).

The current study was conducted on two groups, each with 20 samples (castings). Each group was cemented with one of the provisional luting agents and tested. The provisional luting agents evaluated were TempBond (Kerr Co, Italy) and Dycal (DENTSPLY, Tokyo, Japan).

Weighted amounts of luting agents were mixed according to the manufacturer's instructions; and applied the mixed cement to intaglio surface of the coping. The coping were gently seated on the abutments and held in place with finger pressure for 10 seconds and then placed under 5kg weight for 5 minutes at room temperature.

Excess provisional luting agent was removed with a plastic scaler.

The specimens were stored in 100% relative humidity for 24 hours at 37°C until tested.

The specimens were attached to a universal testing machine (Zwick/Roell Z020, Ulm, Germany) by clamping them directly to the loop attachment.

The machine was used to apply vertical tensile forces at a crosshead speed of 5mm per minute, to dislodge the castings from the abutments. The peak load to dislodge was documented (N) and used to indicate the retentive values. After the castings were dislodged from the abutments, the abutments were placed in provisional cement removal solution (Temporary cement remover, Henry Schein Inc, Melville, NY). The cleaned abutments were rinsed with distilled water, dried, and visually inspected to ensure complete removal of the provisional luting agent.

After cleaning, the next set of provisional restoration was luted to the abutment with another luting agent, stored in 100% relative humidity for 24 hours at 37°C, and tested in the same manner. Ultimate retentive strength of each specimen was analyzed using a two-way analysis of variance (ANOVA) ($\alpha=0.05$).

RESULTS

The results of the statistical analysis, two-way ANOVA, are summarized in table 1.

To achieve the homogeneity of variances in two-way ANOVA, the data of peak loads (retention) were changed to natural logarithm (Ln-R). Two-way ANOVA (Ln-R) found no difference in retentive strength when Dycal was used with two different designs of abutments ($P=0.617$). However, when the abutments were cemented with Temp Bond, the mean retention (Ln-R) was significantly higher in 3-wall abutments than the intact abutments ($P=0.027$, Figure 2).

However, there was a significant difference in the mean retention (Ln-R) between Dycal (4.86 ± 0.31) and TempBond (3.98 ± 0.32)

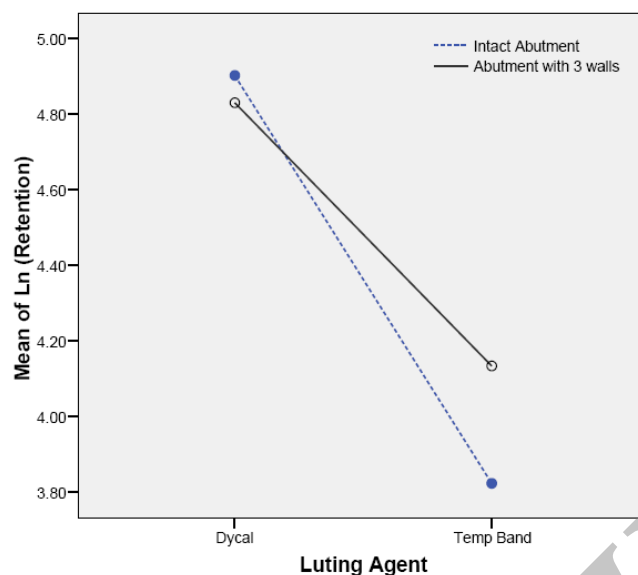


Fig 2. The mean retentive strength profile of the tested cements

($P < 0.001$); and there was no significant interaction effect between the luting agent and the abutment design ($P = 0.053$).

After the removal of cemented abutments, the pattern of cement distribution was evaluated. In all groups, the cement adhered to the fitting surface of the casting but with a block of cement always left in the screw access channel.

DISCUSSION

The retention of implant-supported restoration plays an important role in the success of treatment. The selection of a proper cement is critical, concerning the specific characteristics of each patient and/or site of treatment while bearing in mind how the geometry of the abutment may change the role of cement.

The results of this study rejected the null hypotheses that there would be no significant difference in the retention of cemented crowns whether the implant abutment is intact or has lost one wall without engaging the screw access channel.

Since one wall of the abutment was removed, the internal axial walls played a role in retention by providing extra surface area in the abutment with 3 walls.

These findings are in line with the general consensus that retention is positively correlated with the surface area of the abutment (whether a natural tooth or an implant) [13-15]. Another reason for the improved retention of the 3-wall abutment might be the surface roughness of the internal walls [16, 17].

Table 1. The Mean (Ln-R) value of the retentive strength (N) and the results of two way ANOVA for the two tested cements

	Intact abutment		Abutment with 3 walls	
	Dycal	TempBond	Dycal	TempBond
Mean±SD (Retention)	141.2±36.7	46.9±10.2	128.3±27.6	65.3±18.8
Mean±SD (Ln (Ret.))	4.9±0.37	3.9±0.23	4.83±0.25	4.13±0.33
Effects	Abutment design× Luting Agent Interaction ($P = 0.053$)			

As explained by Tan [13] et al, unlike the external axial walls, the internal walls were not coated with smooth titanium nitride. When the abutment was prepared, the smooth titanium nitride coating was partially removed by the removal of one axial wall. The rough surface of the modified abutment along with the internal axial walls may have provided more retention [13].

Another possible explanation for the improved retention, seen in modified abutment when compared to an abutment with 4 intact walls, was the presence of an open screw access channel. As it was reported in studies that examined the natural abutments [18-20], the screw access channel may act as an internal vent or escape channel, allowing for more complete seating of the casting. The cementation of the casting over the abutment with 4 intact axial walls may have produced a large amount of hydraulic pressure as the excess cement leaked out. This may have resulted in an incomplete seating of the casting as well as a thicker layer of cement on the axial walls. In addition, it has been shown that the extra retention may have resulted from the undercut formed within the screw access opening relative to the axial surface of the modified abutment [21, 22]. They showed that complete filling of the screw access channel can reduce the removal force of a coronal restoration cemented with TempBond [21]. These findings are in line with the current study results.

Considering all the above, a clinician should carefully consider the choice of cement when the risk of component loosening is high. In such situations, a weaker cement like TempBond, might be clinically effective allowing restoration retrieval. These results are in accord with those of Emms et al [21].

Conversely, when the retentive form of the abutment is compromised for example by loss of length [23], cementation with calcium hydroxide (Dycal) might be stronger than eugenol containing cements such as zinc oxide eugenol (TempBond).

This material is hardened to a more brittle consistency and is slightly stronger than TempBond. The mode of cement failure is an important factor in cement selection. Adhesion of the cement to the abutment can cause difficulty in removal and damage the abutment surface [23]. The cement failure in the 3-wall abutment group appeared to be in a more gradual manner. Cement adhered to the metal surface with a block of cement always left in the screw access channel. This is almost certainly a consequence of part of the channel forming an undercut relative to the axial surfaces of the abutment, and is a potential source of retention that does not appear to have received attention to date. It may explain why the 3-wall group had a higher removal force than the 4-wall group, as force was required to cause a cohesive fracture within the TempBond and Dycal. A similar effect can be expected with other cements, including permanent luting agents; but further work is required to confirm this.

However, the limitations of this study should be noted from the outset, since it only investigated the retention and not the resistance. Clinically, removal of casting might not employ forces along a single path of withdrawal.

CONCLUSION

Within the limitations of this in-vitro study, we can draw the following conclusions:

- 1) Minor modifications to an abutment can have a slight influence on retention, even though not statistically significant.
- 2) The retention of the cement-retained implant restoration can be improved by the type of the temporary cement used.

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