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Original Article

Evaluation and Comparison of the Film Thicknesses of Six Temporary Cements before and after Thermal Cycling

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ABSTRACT

Aim: Temporary cement can be applied for both permanent and temporary cementation of implant-supported fixed restorations. These cements must have certain physical and mechanical properties. Specifically, the film thickness directly affects the cement's clinical success. The aim of this study was to evaluate and compare the film thicknesses of six temporary cements before and after thermal cycling. **Materials and Methods:** Eighty-four metal copings with uniform holding loops were fabricated and divided into 12 groups of seven samples each. Six of these groups were subjected to a thermal cycling process. The copings were cemented to solid implant abutments (Implance Solid Abutment, 3.5-mm cervical diameter, 2 mm high, 6° taper, Implance Dental Implant System; AGS Medical, Trabzon, Turkey), using six different types of cement. The fitting surfaces were coated with the luting cements. After steeping in artificial saliva for 24 hours, the specimens were subjected to pull-out testing using an Instron machine. Specimens in the thermal cycling groups were subjected to 700 thermal cycles (36–55°C) prior to pull-out testing. **Results:** The Mann–Whitney U test revealed significant differences between the retention values of the thermal cycling (+) and thermal cycling (–) groups ($U = 153.0$, $P < 0.01$). The retention values of the groups subjected to thermal cycling were significantly lower than those of the cements that were not subjected to thermal cycling. Thermal cycling also affected the film thickness significantly (Wilcoxon signed rank test, $Z = -5.533$, $P < 0.001$). **Conclusions:** Thermal cycling affects the film thickness and retention of temporary cements significantly. The retention value was significantly higher for glass ionomer cement than for the other cements tested, and this cement also exhibited greatest film thickness.

KEYWORDS: *Cementation, Dental implant, Film Thickness, Thermal cycling*

INTRODUCTION

The temporary cementation of permanent and temporary restorations on prepared abutments has several clinical purposes, such as the maintenance of aesthetics, oral hygiene, periodontal health and occlusal harmony; improvement of speech; protection of the pulp; and prevention of tooth decay and displacement.[1-5] Cementation failure is often the result of insufficient and/or deteriorating adhesive binding[6,7] and can result in microleakage and related discoloration, marginal fracture, secondary decay, postoperative sensitivity, and pulpal disease.[6]

Temporary cementation is also used to retain prostheses on dental implants. Some clinicians prefer the cementation of implant-supported fixed restorations to avoid risking their components in the event of abutment screw loosening or restoration failure.[8] On the other hand, screw-retained prostheses have the advantage of easy retrievability for reservicing, replacement, or salvaging of the restorations and implants, which is

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highly beneficial, considering the need for periodic replacement of prosthodontic components, the occasional fracture of fastening screws or abutments, the need for prosthesis modification after implant loss, and the need for surgical reintervention.[9] Cement-retained prostheses offer optimal aesthetics and occlusion[9] and facilitate the passive fit of superstructures and easier axial loading; they allow for the use of traditional prosthetic techniques with fewer acrylic resin or porcelain fractures, and they require fewer appointments.[10] Additionally, the luting agent may act as a shock absorber.[9,11] Temporary cements may be preferable in cases requiring abutment retorquing or professional cleaning of the implant neck.[9]

This study was motivated by the assumption that temporary cements have less retentive strength than permanent cements.[12] Recent laboratory findings support this suggestion.[13,14] Some authors have recommended the use of temporary cementation only for multi-unit implant-supported fixed restorations.[13] Consequently, the application of temporary cements to implant-supported fixed restorations has become widespread.[15] On the other hand, most reports of nonadherence at the abutment–restoration margin, marginal microleakage, and microbial flora have been attributed to the use of temporary cement.[16-18]

Temporary cement can be used for the permanent and temporary cementation of implant-supported fixed restorations. These cements must have certain physical and mechanical properties.[19] This is imperative to prevent microleakage and to mechanically lock the restoration in place, thereby preventing its dislodgment during mastication.[20] Specifically, film thickness has a direct effect on clinical success.[20] The type of cement and correct adaptation of the prosthetic component to the abutment walls are also important.[8] Variations in adaptation may lead to thicker cement layers, resulting in plaque accumulation and peri-implantitis.[21]

Therefore, the luting space should be minimized to improve the fit of the restoration, expose the minimal amount of luting material to oral fluids, and minimize polymerization contraction stress.[22] No consensus has yet been reached regarding an appropriate minimum value of luting space, but a 50–100-µm range seems to be most convenient.[23-25] ISO standards require film thicknesses of ≤25 µm at the time of seating for water-based luting cements, and ≤50 µm for resin-based cements.[26]

Few studies to date have examined the film thickness of temporary cements on dental implants.[27,28]

In addition, no report has yet investigated the described changes in the film thicknesses of temporary cements after thermal cycling. The aim of the present study was to evaluate and compare the film thicknesses of six temporary cements before and after thermal cycling.

The null hypothesis of this study was that thermal cycling does not affect the film thicknesses of cements.

MATERIALS AND METHODS

Six temporary cements were evaluated in this study [Table 1]. Each group included seven abutments. Twelve groups were evaluated in this study, six of which were subjected to a thermal cycling process. The specimens which were subjected to thermal cycling process were named as Thermal (+), and which were not subjected to thermal cycling were named as Thermal (-).

Eighty-four solid implant abutments (Implance Solid Abutment, 3.5-mm cervical diameter, 2 mm in height, 6° taper, Implance Dental Implant System; AGS Medical, Trabzon, Turkey) were used. Plastic hex copings, custom-made by the implant manufacturer, were sprued, and a uniform holding loop was fabricated onto each specimen to facilitate coping mounting in an Instron machine for subsequent pull-out testing [Figure 1]. These molds were invested and cast in Co/Cr alloy. Each abutment–coping casting was paired and numbered for the purpose of identification during the cementation procedure [Figure 1].

The implant analogs were embedded in self-curing acrylic resin (Imicryl; Konya, Turkey) [Figure 2]. The implant abutments were torqued onto implant analogs of the same brand (Implance Dental Implant System; AGS Medical, Trabzon, Turkey). Prior to cementing, both the inner surfaces of the copings and the abutment surfaces were wiped carefully with 99.5% ethanol for 30 seconds using a clean soft cloth, and then dried with clean compressed canned air.

Initial measurements (±1-µm precision) of the abutment cast coping complex for each specimen were taken in triplicate using electronic calipers (Absolute Digimatic; Mitutoyo Corp., Kanagawa, Japan) [Figure 3].[29]

Six cement types were evaluated in this study [Table 2]. Hand mixing was performed for the recommended time after the cements' extrusion onto a sheet of coated paper. The same operator applied all cements to the internal aspects of the abutment sleeves, as evenly as possible, at room temperature (21–25°C) under fluorescent light, and then seated the abutments immediately using a standard force of 5 KgF for 10 minutes, in accordance with American Dental Association Standard No. 96.[26] Excess cement was removed from the margins using a Hollenbach 3 carver (Dentsply, Mölndal, Sweden). A second round of measurements was taken in triplicate for each specimen, in order to evaluate the film thicknesses of the cements.

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The fitting surfaces of the copings were coated with the luting cement. After steeping for 24 hours in artificial saliva, the thermal cycling (-) groups were subjected to pull-out testing using an Instron machine [Figure 4].

The maximum force required to remove the cast coping from the abutment was recorded as the retentive force.

Specimens in the thermal cycling groups were subjected to 700 thermal cycles (36–55°C) before pull-out testing.[20]

The normality of the variables' distributions was analyzed using the Shapiro–Wilk test. Descriptive statistics (mean, standard deviation, minimum, median, maximum) were used to characterize the variables. The Mann–Whitney *U*-test was used to compare normally distributed independent variables between groups. The Wilcoxon signed rank test was used to compare non-normally distributed dependent variables between groups. The level of statistical significance was set at 0.05, and statistical analysis was performed using MedCalc software (version 12.7.7; MedCalc Software, Ostend, Belgium).

RESULTS

Table 3 lists the mean thicknesses of the six cements tested.

The Mann–Whitney U-test revealed significant differences between the retention values of the thermal cycling (+) and thermal cycling (–) groups [$U = 153.0$, $P < 0.01$; Table 4]. The retention values of the groups subjected to thermal cycling were significantly lower than those of the cements that were not subjected to thermal cycling [Figure 5].

The Wilcoxon signed rank test revealed that thermal cycling significantly affected the film thickness [$Z = -5.533$, $P < 0.001$; Table 5].

Table 1: The group names

	Group names						*n*
Thermal cycling (+)	RE+	TNE+	TC+	TE+	GC+	RNE+	7
Thermal Cycling (-)	RE-	TNE-	TC-	TE-	GC-	RNE-	7

Figure 1: The abutment and cast coping complex

Figure 2: The specimen were embedded in self-curing acrylic resin

Figure 3: The first measurement of abutment coping complex without any cement inside

Figure 4: The pull-out test of the specimen in Instron machine

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Table 2: The cements evaluated in the study

Cement	Manufacturer	Classification	*n*	Group	Mixing method
TempBond	Kerr	Zinc oxide/eugenol	7	TE	Tubes (hand mix)
RelyX™ Temp E Cement	3M	Zinc oxide/eugenol	7	RTE	Tubes (hand mix)
Tempbond NE	Kerr	Non Zinc oxide/eugenol	7	TNE	Tubes (hand mix)
RelyX™ Temp NE Cement	3M	Non Zinc oxide/eugenol	7	RNE	Tubes (hand mix)
TempBond Clear	Kerr	Triclosan thematic dual cure translucent cement	7	TC	Tubes (hand mix)
Fuji TEMP LT™	GC	Glass Ionomer	7	GC	Tubes (hand mix)

Table 3: The mean cement thickness values

Brand	Mean (Newton)	SD	*n*
RE	4.7	2.7	14
TNE	5.3	2.9	14
TC	5.2	3.8	14
TE	6.2	5.5	14
GC	103.3	121.9	14
RNE	41.7	92.7	14

SD=Standard deviation

Table 4: Mann-Whitney U-test results

Thermal cyclus	Mean	SD	*n*	Significant *P**
Thermal cyclus (+)	18.1	17.1	42	<0.001
Thermal cyclus (-)	59.5	27.4	42	0.170
Total	38.8	30.8	84	<0.001

*Shapiro Wilk (the pull-out datas of the samples that were not subjected to thermal cycling were normal distrubuted (*P*=0.170), the pull out datas of the samples that were not subjected to thermal cycling and all the cements were not normal distrubuted (*P*<0.001). *n*=Number of the specimens that were subjected to thermal cyclus, and that were not subjected to thermal cyclus. SD=Standart deviation

Table 5: Wilcoxon signed rank test results

Thermal cyclus	Mean	SD	*n*	Significant *P**
Prethermal cyclus	36.2	86.9	42	<0.001
Postthermal cyclus	86.3	105.5	42	<0.001

*Shapiro Wilk (The datas of the samples that were subjected to thermal cycling were not normal distrubuted (*P*<0.001) *n*=Number of the specimens that were subjected to thermal cyclus, and that were not subjected to thermal cyclus. SD=Standart deviation

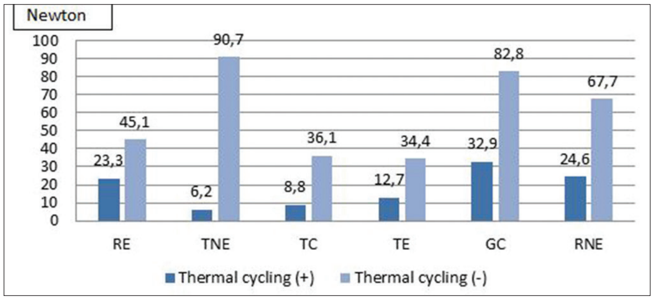

Figure 5: The cements retention graphic

Discussion

Temporary luting cements must have appropriate mechanical and physical properties, and the film thickness of the luting agent directly affects clinical success.[19,20,30] In this study, the cement type was taken into consideration, following Breeding *et al*.'s[8] observation that it is the decisive factor in retention when retrievability of the implant or prosthesis is required. The application of permanent cements used in traditional prosthodontics is not recommended, as metal abutments do not decay, and these cements are too strong to permit access to the implants.[9]

The cyclic thermal oscillations that occur in the oral cavity are related to eating and drinking habits, and they are impossible to emulate realistically.[23] Hence, clinical trials seeking to examine them are expensive, time consuming, and difficult to design. Aging via thermal cycling is a good alternative.[23] In this study, we compared measurements taken before and after thermal cycling to evaluate the increase in film thickness related to water absorption during this process.

Michalakis *et al*.[14] observed dimensional changes in metal components and in four temporary luting agents during thermal cycling. All cements tested in the present study exhibited decreased retention after thermal cycling [Table 5], which suggests that their coefficients of thermal expansion did not match those of the metal components. In addition to decreased retention, the cements exhibited increased film thickness after thermal cycling. For this reason, we rejected the first hypothesis of this study.

Mansour *et al*.[31] tested the retention of six cements on solid abutments without thermal cycling, and reported that Temp-Bond yielded the weakest value (mean, 3.1 N). In this study, TE had a mean value of 12.7 N. This difference can be attributed to the use of different implant abutment systems.

The values obtained for the provisional cements are comparable to those reported by Kious *et al*.[26] for six cements at different timepoints, although thermal cycling was not performed in that study. Data from previous studies have indicated that glass ionomer cement yields superior retention results.[32,33] The glass ionomer cement used in this study is a cement that was marketed for use in temporary cementation, according

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to the manufacturer's instructions.[34] Glass ionomer cement exhibited significantly greater retention than the other cements tested; however, it also had the greatest film thickness, inconsistent with the findings of Ladha and Verma[35] The non-zinc oxide/eugenol cement used in this study, TNE, was the weakest cement among the thermal cycling (+) groups, whereas TE was the weakest cement among the thermal cycling (–) groups. Although TNE exhibited a significant decrease in retention after thermal cycling, its film thickness did not change significantly compared with the other cements.

Additionally, cements that included eugenol had demonstrably superior retention characteristics. No statistically significant differences were observed between calcium hydroxide (Lifes)-reinforced zinc oxide eugenol (ZOE) (IRMs) and ZOE (Temp Bonds).[8] In this study, the newer cements on the market and those that had not previously been compared were tested.

The machined abutment surfaces used in this study were not modified with any preparation technique and were thus relatively smooth. This smoothness may have reduced the micromechanical cement–abutment interlocking, leading to lower cement retention values.[31]

The temporary cements investigated in this study exhibited wide-ranging capacities for retaining castings under the test conditions. Despite application of the thermal cycling process, prediction of clinical performance remains difficult, with more *in vitro* and *in vivo* studies needed.

CONCLUSIONS

Within the limitations of the present study, we can conclude that:

1. Thermal cycling affected the film thickness and retention of provisional cements significantly
2. Glass ionomer cement exhibited significantly greater retentive properties, but also greater film thickness, than the other cements tested
3. Change in the film thickness did not directly affect retention
4. The non-zinc oxide/eugenol cement used in this study, TNE, was the weakest cement among the thermal cycling (+) groups. It may be advisable to lute the restoration with a glass ionomer provisional cement if long-term cementation is desired.

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Conflicts of interest

There are no conflicts of interest.

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