

# Influence of the temperature on the cement disintegration in cement-retained implant restorations

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## SUMMARY

The aim of this study was to estimate the average disintegration temperature of three dental cements used for the cementation of the implant-supported prostheses. One hundred and twenty metal frameworks were fabricated and cemented on the prosthetic abutments with different dental cements. After heat treatment in the dental furnace, the samples were set for the separation to test the integration of the cement. Results have shown that resin-modified glass-ionomer cement (RGIC) exhibited the lowest disintegration temperature ( $p < 0.05$ ), but there was no difference between zinc phosphate cement (ZPC) and dual cure resin cement (RC) ( $p > 0.05$ ). Average separation temperatures: RGIC –  $306 \pm 23^\circ\text{C}$ , RC –  $363 \pm 71^\circ\text{C}$ , it could not be calculated for the ZPC due to the eight unseparated specimens. Within the limitations of the study, it could be concluded that RGIC cement disintegrates at the lowest temperature and ZPC is not prone to break down after exposure to temperature.

**Key words:** Cement-retained restoration, Temperature, Cement disintegration, Restoration retrievability.

## INTRODUCTION

Fracture of the veneering material was shown to be the most common technical complication of the implant-supported restorations (1). Reported failure rate appears to be 4.6% in 5 years for the single crowns (2) and 5.7% in 5 years (3) for the implant supported fixed partial dentures. Moreover, the frequency of ceramic chipping or fracture in the cross arch type implant supported bridges delivered for totally edentulous patients was reported to be as high as 38.1% in 3 years (4).

If permanently cemented implant-supported restoration needs to be removed, the clinician has two choices either to cut off the crown from the prosthetic abutment, or to locate the abutment screw from the restoration's occlusal aspect and unscrew the whole abutment-restoration assembly (Figure 1). In the latter

case prostheses are retrieved adhered to the prosthetic abutments (Figure 2). Therefore, the separation of the suprastructure from the abutment without making any damage would be a cost-effective and time saving procedure as the same prosthetic abutment and/or framework could be reused in the fabrication of a newly reconstructed restoration (5).

Ultrasonic vibration and mechanical push down are advocated as methods for the separation of the cemented retainers from their metallic abutments (6), but frequently are not effective. Alysiabi and Felton (5) suggested using the heat for the disintegration of the cement layer and detach of the prosthesis from its substructure. However, the type of luting agent was not described in this study.

Various dental luting cements might be used for the cementation of the implant-supported restorations (7). Therefore, the aim of this in vitro study was to determine the average disintegration temperature of the selected cements. Null hypothesis was formulated stating that all cements disintegrate after exposure to the same temperature.

## MATERIALS AND METHODS

One hundred and twenty standard prosthetic abutments 3.5 mm in diameter (Prodigy; BioHorizons, Birmingham, AL, USA) were used in this

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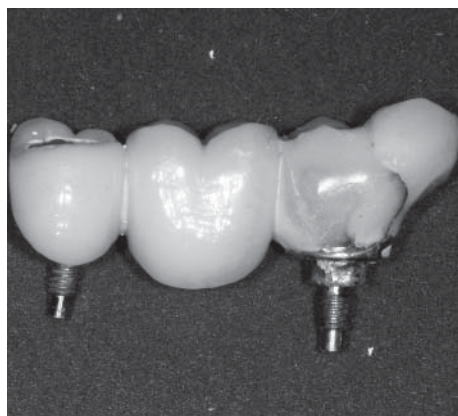
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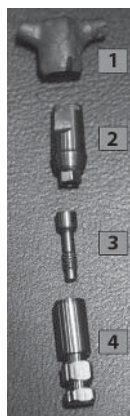
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**Fig. 1.** The occlusal view of cement-retained restoration after location of abutment entries



**Fig. 2.** The restoration is retrieved together with cemented abutment from the implant



**Fig. 3.** Study samples (1 - metal framework with extensions; 2 - prosthetic abutment; 3 - abutment with screw; 4 - laboratory implant)



**Fig. 4.** Separated framework from the abutment after heating

study. The same amount of metal frameworks with two 4×2 mm extensions and occlusal openings *was fabricated, using the base alloy* (Starbond CoS, S&S Scheftner GmbH, Mainz, Germany), consisting of Co 59.0%, Cr 25.0%, W 9.5% and Mo 3.5% (Figure 3). The prosthetic abutments and the inner surfaces of the frameworks were sandblasted using 250 μm aluminum oxide particles (Renfert, Hilzinger, Germany) under 2 bar air pressure for 5 seconds. Passive fit of the restorations was achieved using three layers of a die spacer (Pico Fit, Renfert, Hilzinger, Germany).

The specimens were divided by 40 into three groups. Each group has been set for cementation with the following cements – resin-modified glass-ionomer cement (RGIC) – Fuji Plus (GC, Tokyo, Japan), zinc phosphate cement (ZPC) – Hoffmann's (Dental Manufaktur GmbH, Berlin, Germany) and dual cure resin cement (RC) – Panavia F2.0 (Kuraray Medical, Osaka, Japan). The top of each prosthetic abutment and occlusal openings were temporarily closed with dental wax (Wax Pak, 3M ESPE Dental Products, Germany) and composite material Gradia Anterior (GC, Tokyo, Japan) before cementation. The cements were mixed according to the manufacturer's instructions; a thin layer was applied to all internal surfaces of the crowns and seated onto the abutment with a gentle finger pressure. The cement excess was removed and the specimens were left for 24 hours for the total set. Later specimens were placed in the dental furnace (Programat P80, Ivoclar, Vita Zahnfabrik) on a fibrous firing supporting pad. The program for heating was scheduled as follows: 1) starting temperature 200°C; 2) increasing temperature 50°C per minute until 300°C is reached; 3) five minutes holding time; 4) cooling in the room temperature.

After cooling each framework-abutment unit was connected to the laboratory analog. Dental tech-

nician tried to remove the superstructure from the abutment manually. If the removal of the framework was unsuccessful, the specimen was put in the dental furnace again with the starting temperature increased by 50°C. The maximum starting temperature was 650°C and the maximum holding temperature was 750°C, according to the heating schedule. In the case of successful framework removal from the abutment (Figure 4), the holding temperature was considered as a disintegration temperature of the cement.

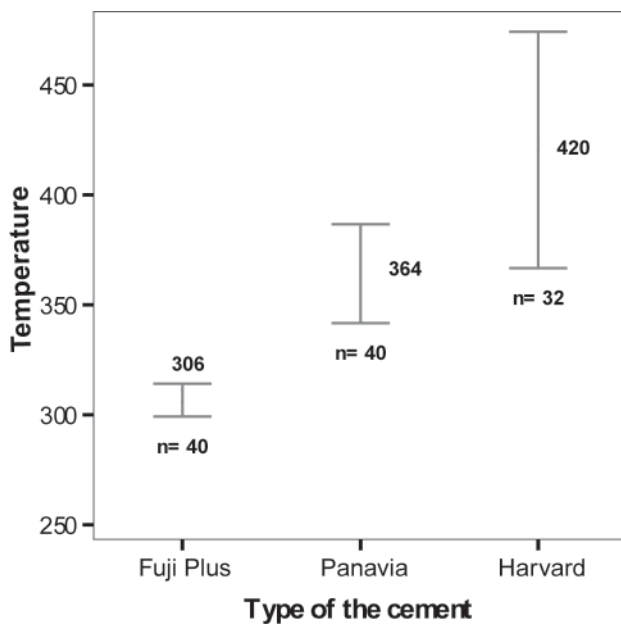
Statistical analysis was carried out using SPSS software for Windows v.16 (SPSS Inc., Chicago, USA). The mean values of the temperature were calculated and compared between the groups using one-way ANOVA. Significance level was set to 0.05 with a confidence interval of 95%.

## RESULTS

The number of the separated specimens in each group depending on the temperature could be seen in Table 1. The attention should be paid to the fact that 8 specimens cemented with ZPC could not be separated after heating in the available temperatures. The average disintegration temperatures of the selected cements are presented in Table 2. The average disintegration temperature of RGIC was statistically significantly lower than the disintegration temperatures of RC and ZPC ( $p < 0.05$ ). For the average temperature comparison between the groups 8 ZPC missing values were not included (Figure 5).

## DISCUSSION

The null hypothesis was rejected, because cement type had influence on the frameworks separation



**Fig. 5.** Average disintegration temperatures (error bars show 95.0% CI of the mean)

ability from the implant abutment after exposure to temperature. RGIC disintegrated at the lowest temperature, followed by RC and ZPC, making this difference statistically significant. In addition, 8 specimens in ZPC group could not be separated at all, despite the high temperature and physical efforts.

Sandblasted prosthetic abutments were used in the study due to the advice that sandblasting increases retention properties of the in clinical situations of implant supported cement retained prostheses (8). The maximum holding temperature of 750°C was selected to avoid the negative influence of the heat on the titanium abutments and porcelain (9).

**Table 1.** Number of specimens separated after heating depending with regard to the temperature

C°	RGIC	RC	ZPC
300	37	20	17
350	1	0	3
400	2	13	0
450	-	3	0
500	-	4	0
550	-	-	0
600	-	-	11
650	-	-	0
700	-	-	1
750	-	-	0
<b>Total</b>	<b>40</b>	<b>40</b>	<b>32*</b>

RGIC – glass ionomer with resin

RC – resin cement

ZPC – zinc phosphate cement

\* 8 unseparated specimens not included

Oxidized layers appear on the titanium surface under exposure to temperature higher than 750°C (10). Surface oxidation may preclude the use of the same titanium abutment, as it may not fit to the implant. This is the reason why as low as possible disintegration temperature of the cement is desirable and it seems that RGIC provides the best fulfillment of this condition. Moreover, not only retention properties should be kept in mind when selecting the luting agent, but also the availability to clean the cement excess intraorally. RGIC and RC are very hard to remove due to the resin component, especially if the margins of the crown are held subgingivally (11). Therefore the individual abutments with visible cementation margins should be selected if total cement removal is desired (12).

Manual separation technique was chosen to simulate the dental technicians attempt to detach the restoration from the prosthetic abutment in everyday practice. Standardized pull-out testing would give force control, however the measurement of the force was not the intention of the authors. Moreover, in the case of a clinical veneer fracture complication dental technician would try to detach the crown manually from the prosthetic abutment. Therefore, the manual separation technique was chosen to imitate the clinical reality as close as possible and replicate the actions of the dental technician. Similar methods with no force control are used in vitro studies, for example, when braces are detached from the teeth and enamel fractures are evaluated (12).

Literature regarding the influence of the cement type on the separation of the crown or framework from the prosthetic abutment under exposure to temperature is very sparse. The search could identify only one case study which described successful usage of temperature to remove a restoration from the prosthetic abutment (5). Authors have recommended using this approach for the cemented restorations, affected by abutment screw loosening. After successful disconnection, the abutments were retightened back to the implants, resulting in the cost-effective and time saving procedure.

**Table 2.** Disintegration temperatures of each cement

Cement	Average temperature $\pm$ SD °C
RGIC	306.25 $\pm$ 23.170 °C
RC	363.75 $\pm$ 70.699 °C
ZPC	420.31 $\pm$ 149.655 °C

RGIC – glass ionomer with resin

RC – resin cement

ZPC – zinc phosphate cement

SD – standard deviation

\* could not be evaluated

The results of the present study have shown that RGIC disintegrates at the lowest of applied temperatures. Thus the separation of the restoration is the most simple and the negative effect of the heat to the abutment and framework is reduced, compared with the other luting agents. It could be speculated that this type of the luting material may be suitable for the permanent cementation of the implant-supported restorations, if the easy and simple separation of a crown from the prosthetic abutment is desired, in the case of complication or remake. However, not only retentive properties of the cement should be considered when selecting

the cement in the clinical case. ZPC appeared to be the most resistant to heat treatment from the tested dental cements.

## CONCLUSIONS

Within the limitations of this study, the following conclusions can be made: 1) frameworks cemented with ZPC were the most complicated or even impossible to remove; 2) RGIC disintegrates at the lowest temperature, therefore may be convenient to use for cement-retained implant restorations, if other requirements are maintained.

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