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Impact on Retrievability by Cement Variety for Implant Restorations Equipped with a Lingual Slot

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Purpose: The purpose of this study is to measure and compare the removal torques of different cements applied in attachments of zirconia restorations on titanium (Ti) abutments fitted with retrievable cement-type slot (RCS) on the lingual side for the better retrievablity by use of a slot driver.

Materials and Methods: Three types of cements were used in the experiment: two permanent cements in RelyX™ U200 (RU) (3M ESPE) which is a resin cement and FujiCem™ (FC) (GC) which is a resin-modified glass ionomer cement, and a temporary cement in Freegenol™ temporary cement (TC) (GC). Measurements of removal torques were conducted as follows; an attached sample was fixed on the equipment customized for the experiment; a slot driver was connected to a MGT12 (Mark-10 Corp.), a torque measurement instrument; the sample had the driver fitted to its RCS and then was rotated until the it was removed; and finally, the maximum torque value was recorded.

Result: As for the removal torque measurement results, the average values were 47.9±2.6 Ncm for RU, 43.4±1.5 Ncm for FC, and 20.9±1.0 Ncm for TC. The statistical analysis using Kruskal-Wallis test yielded the significance probability of $P<0.05$ ($P=0.002$), which confirmed the presence of significant differences between the three groups.

Conclusion: All three cements exhibit clinically acceptable levels of removal torque when applied to an upper zirconia implant restoration fitted with a lingual slot, with RU and FC, the two permanent cements, having the significantly higher values than that of TC, the temporary cement.

Key Words: Dental implant; Device removal; Resin cements; Torque

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Introduction

Cement-retained implant restorations have many advantages over screw-retained implant restorations in terms of aesthetics, occlusions, costs, passive fits, and others, as reported numerously by the previous studies[1,2]. However, in cases that require retrievals of the restorations for loose bolts, fractures of the upper parts, and other likewise reasons, accesses to the screw holes are usually blocked by the restorations themselves. The lack of retrievability, such that it is difficult to retrieve the restorations without possible damages to the upper parts or abutments, has been indicated as the most serious flaw in the cement-retained implant restorations.

Considering the much reduced need for the restoration retrieval due to the increased success rate of implant treatments and more frequent use of customized abutments for restoration fabrication than manufactured ones, frequency of the cement-retained implant restorations in clinical application should expectedly rise in the near future. Yet as there exist possibilities of loose or fractured bolts from occlusion force applied on the implants, bone loss caused by residual cement on gums, and other problems[3,4], retrievability should be taken as a serious factor in the fabrications of the restorations.

So far, numerous methods have already been introduced as a way to establish retrievability in cement-retained implant restorations. Clausen[5] presented an approach of connecting a restoration and an abutment with a lingual bolt for an additional support and an easier removal afterwards. Others have suggested use of X-ray images to locate the screw hole[6], or marking the hole location within an aesthetically acceptable extent[7]. On the other hand, Schweitzer et al.[8] proposed a procedure of adding a retrievable slot on the lingual side of a restoration to enable its retrieval.

One of the most commonly researched areas for retrievability of cement-retained implant restorations is the type of cement used to attach the abutment and the restoration. Since the problem of low retrievability in the restoration had first been addressed, several reports have been published with recommendations of temporary cements in place of permanent ones for the restoration attachment[9,10]. Mehl et al.[11] claimed a need for semi-permanent cementation, an intermediate state between permanent and temporary attachment, in improving retrievability of the restorations, and proposed use of zinc phosphate cement or glass ionomer (GI) to achieve it. On the contrary, other reports recommended employment of permanent cements to avoid long-term prognostic complications caused by the unstability of temporary cements[12-15]. For zirconia restorations, usage of which have recently been rising in practice, resin cements are highly endorsed[15]. Therefore, the stronger research demand exists for determination of which cement would be the optimum choice for both prognosis of implant treatment and retrievability.

The purpose of this study is to measure and compare the removal torques of different cements applied in attachments of zirconia restorations on titanium (Ti) abutments fitted with retrievable cement-type slot (RCS) on the lingual side for the better retrievablity by use of a slot driver. The comparison result should reveal the best selection of cement for optimum retentivity and retrievability of the restorations.

Materials and Methods

1. Materials

Three types of cements were used in the experiment: two permanent cements in RelyX™ U200 (3M ESPE, St. Paul, MN, USA) which is a resin cement and FujiCem™ (GC, Tokyo, Japan) which is a resin-modified GI (RMGI) cement, and a temporary cement in Freegenol™ temporary cement (GC). Table 1 is a tabulated summary of the cement types used

Table 1. Luting cements used in this experiment

Abbreviation	Proprietary name	Type	Manufacturer
RU	RelyX™ U200	Self-adhesive resin cement	3M ESPE (St. Paul, MN, USA)
FC	FujiCem™	Resin-modified glass ionomer cement	GC (Tokyo, Japan)
TC	Freegenol™ temporary cement	Non-eugenol temporary cement	GC (Tokyo, Japan)

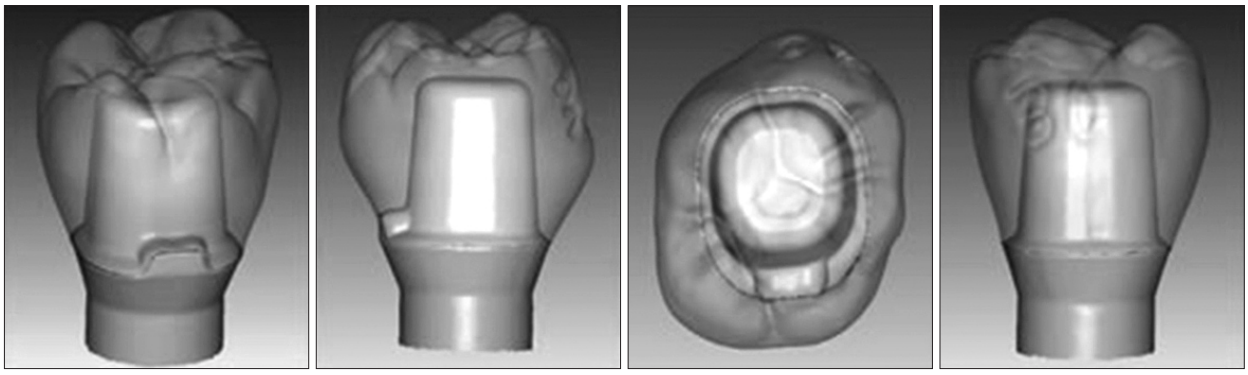

Fig. 1. Design process of the monolithic crown.

in the experiment.

2. Experimental Sample Preparation

Fifteen Ti abutments with round corners were fabricated as the customized abutments for the experiment. The abutments had marginal shapes of sloped shoulders with 0.6 mm thickness, and a dimension of 6 mm width, 6.5 mm length, 6 mm height, and 8° convergent angle. One of their sides was fitted with a shelf shape of 2 mm width and 1 mm depth for insertion of the slot driver later. Every numerical dimension was determined after an analysis of average dimensions of customized abutments made for clinical practice by the Department of Prosthetic Dentistry in Kyungpook National University Dental Hospital.

Ceramill CAD/CAM (computer aided design/computer aided manufacturing) system was used in fabrication of zirconia restorations to be attached to the Ti abutments. As for the fabrication procedure, scans of the abutments by Ceramill Map400 (Amann Girrbach, Koblach, Austria) yielded results in surface output format (stereolithography [STL] files), which were then used to design the upper restoration with the attachment side shaped as the first molar on the right upper jaw, 35 μm interval for the interior cement, and 1 mm minimum thickness except for the marginal portions. The finished design was transferred to Ceramill Motion 2 (Amann Girrbach), which then used it to cut Ceramill Zolid (Amann Girrbach) zirconia blocks to make the restorations. Fig. 1 shows the design process of the zirconia restorations.

The finished zirconia restorations were then recut using a handpiece tool and a bur for prosthetic dentistry to have a 1 mm-wide gap at the site on the bottom to fit the shelf of the Ti abutments. This allowed for a rectangular-shaped RCS with 2 mm width, 1 mm length, and 1 mm depth to form. Fig. 2 shows the image of samples with the abutments before and after the formation of the RCS.

3. Cement Attachment and Measurement of Removal Torques

Cements were mixed per instruction by the manufacturers, and then were applied to the interiors of the zirconia restorations, before applying 50 N force for 10 minutes to cure them. Afterwards any resid-

Fig. 2. Specimens before (left) and after (right) the fabrication of retrievable cement-type slot.

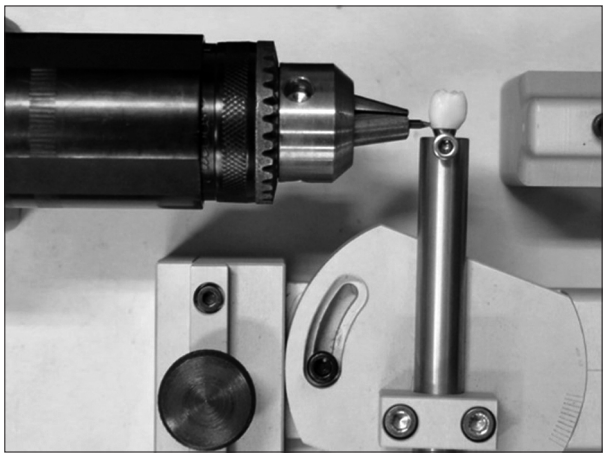

Fig. 3. The custom-made device used for measuring removal torque in this experiment.

ual cements were removed from the samples before being stored in distilled water at room temperature for 24 hours. Such processes were repeated for 15 samples, 5 per each of the three cements.

Measurements of removal torques were conducted as follows; an attached sample was fixed on the equipment customized for the experiment; a slot driver was connected to a MGT12 (Mark-10 Corp., Copiague, NY, USA), a torque measurement instrument; the sample had the driver fitted to its RCS and then was rotated until the it was removed; and finally, the maximum torque value was recorded (Fig. 3).

Table 2. Removal torque values according to luting cements (Ncm)

Abbreviation	Number	Minimum	Maximum	Mean±SD
RU	5	44.6	51.5	47.9±2.6
FC	5	42.0	45.7	43.4±1.5
TC	5	19.5	22.0	20.9±1.0

RU: RelyX™ U200, FC: FujiCem™, TC: Freegenol™ temporary cement.

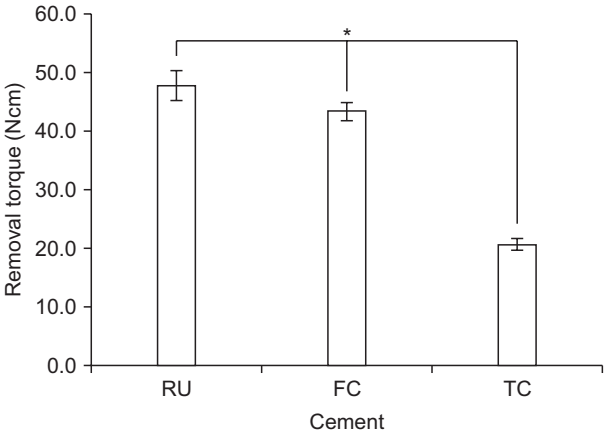

Fig. 4. Removal torque values according to luting cements. RU: RelyX™ U200, FC: FujiCem™, TC: Freegenol™ temporary cement. Asterisk indicates significant difference by Mann-Whitney U-test at α=0.05.

4. Statistical Analysis

The statistical analysis had been performed to examine the value significance for each cement group by conducting a Kruskal-Wallis test, which was then followed with Mann-Whitney U test as a post hoc test (α=0.05). IBM SPSS Statistics 20.0 for Windows (IBM Co., Armonk, NY, USA) had been used for all statistical treatments.

Result

As for the removal torque measurement results, the average values were 47.9±2.6 Ncm for RelyX™ U200 (RU), 43.4±1.5 Ncm for FujiCem™ (FC), and 20.9±1.0 Ncm for Freegenol™ temporary cement (TC). The removal torque values of the samples for each cement type are summarized in Table 2.

The statistical analysis using Kruskal-Wallis test yielded the significance probability of $P<0.05$ ($P=0.002$), which confirmed the presence of sig-

nificant differences between the three groups. The post hoc test by Mann-Whitney U test showed that the RU had the significantly higher value than the FC and TC, while the FC also had the significantly higher value than the TC ($P<0.05$). Fig. 4 compiles these results on a graph.

Discussion

This study used three different types of cements to attach the zirconia restorations on the Ti abutments with RCS's to compare their removal torques. The results showed significant differences between the removal torque values for each cement, with the groups using permanent cements such as resin and RMGI cements exhibiting a significantly large value for removal torque than that of a group using a temporary cement ($P<0.05$). This corresponded with the previous researches reporting that resin and RMGI cements have stronger retentivity in cement-retained implant restorations compared to other cements[16-18].

When a cement-retained implant restoration requires a repair, the torque needed for retrieval must not negatively impact the osseointegration of the lower implant fixture. Hallgren et al.[19] reported the shearing strength required to retrieve an osseointegrated implant fixture of 4 mm diameter and 6 mm length along the major axis to be about 290 N. While this value is lower than the retentivity obtained from a temporary cement[16-18], restoration retrieval along the major axis still must be accommodated by a special treatment during the fabrication for favorable retrievability.

According to Nejatidanesh et al.[20], use of a temporary cement or a GI cement in a single implant restoration may cause a detachment caused by loss of cement from minute movements during its use, and therefore, use of a zinc phosphate cement (ZPC) or zinc polycarboxylate cement for a single zirconia restoration, and use of a temporary cement for a multi-unit restorations are recommended to improve the retrievability, while the use of a RMGI or resin cement for a single implant with a molar area on a short abutment are recommended for the better retentivity.

The retentivity of conventional cements is determined by combination of physical strength of the cements and micro-mechanical retentivity from the filler particles spread on the abutments. In case of ZPC, the most retentivity originates from the latter, so it would have the significantly lower retentivity compared to resin or RMGI cements when used for attachment on smooth abutments made with mechanical milling instead of teeth-cutting[20]. Likewise, GI cements have also been reported to have much low retentivity on metal implant abutments for the same reason[21].

The purpose of this study is to suggest a potential for an implant restoration as proposed by Schweitzer et al.[8] that secures retrieval convenience using a lingual slot while optimizing for retentivity by uniformly applying a single cement type, unlike the regulation of cements in the final attachment for the better retrievability. Therefore, the cements selected for the experiment included resin and RMGI cements, which the previous studies indicated as the most suited for the long-term prognosis of the implant[15] but not for convenient retrieval[9-11], to investigate if the removal by slot would be more convenient, and a temporary cement, to use as a control with the lowest retentivity in the comparison. ZPC or zinc polycarboxylate cements were excluded as their usage has been less frequent lately, and so were GI cements or implant-designed cements with weak retentivity as they did not fit the scope of this particular study.

As the results of the experiment, the removal torque values for attachment by the permanent cements were between 42.0 Ncm at minimum and 51.5 Ncm at maximum in distribution, while the value for attachment by the temporary cement was

20.9 Ncm in average. The three cements used in the experiment all exhibited the acceptable removal torque values in early post-attachment period for clinical practice, but in scrutiny of the declining retentivity of temporary cements in a long term use, a proper selection of cements to fit each clinical situation appears to be quite essential.

Considering that torques of commonly used implant drivers range between 20 to 35 Ncm and that retentivity of the cement drops in a restoration exposed to temperature changes within an oral cavity, the restorations with RCS seem to be easily retrieved using an implant driver with a slot driver fitted, without any need for an extra tool or equipment for the implant retrieval. Repeated occlusions and temperature changes in an oral cavity from food ingestion may generate fatigue in the cement, so using permanent cements would raise the retentivity and the resistance to fatigue. On the other hand, the retrievability enhanced by the RCS on the abutment should yield a clinically improved prognosis.

While the removal torques were measured in this experiment after storage in room-temperature distilled water for 24 hours after attachments, there exist other factors in fabrication for actual clinical use such as being exposed to occlusions or temperature changes. Therefore, a more clinically inclined *in vitro* study must be considered with cyclic loading to reenact occlusions or thermocycling to imitate temperature changes. Additionally, an *in vitro* study such as this work may show different results than those of an actual clinical use, so it compels for a long-term study to inspect the prognosis following more researches and clinical application of the implant restoration with RCS.

Conclusion

The conclusion of this *in vitro* study is as follows:

1. All three cements exhibit clinically acceptable levels of removal torque when applied to an upper zirconia implant restoration fitted with a lingual slot, with RelyX™ U200 and FujiCem™, the two permanent cements, having the significantly higher values than that of Freegenol™, the temporary cement.
2. When the retentivity of a permanent cements is required, installment of a lingual slot to retain the retrievability and application of a permanent cement would lead to a clinically more prudent result with consideration for fatigue resistance of the cement.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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