Australian Dental Journal
The official journal of the Australian Dental Association
AUSTRALIAN DENTAL ASSOCIATION INC.
Australian Dental Journal 2014; 59: 65–69
doi: 10.1111/adj.12148

Effect of screw access channel filling materials on uniaxial retentive force of cement-retained implant restorations

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ABSTRACT

Background: This study aimed to investigate the effect of various abutment screw access channel filling materials on the uniaxial retention of castings cemented onto the abutment using temporary cement.
Methods: Ten straight, regular platform Esthetic Abutments were used. Fifty castings were divided into five groups and the abutment screw access channels were filled with composite resin (Filtek Z 250), light-cured temporary filling (Clip), temporary filling (Coltosol), polyvinyl siloxane impression material (Elite H-D), or polytetrafluoroethylene (PTFE) tape. Castings were cemented and thermal cycled. A uniaxial tensile force with a cross-head speed of 5 mm/min, was applied to the castings until cement failure occurred. One-way analysis of variance was used to perform intergroup comparisons of the mean uniaxial retentive force (URF) values and Tukey's HSD test was used to determine the group causing the difference.
Results: There were statistically significant differences between the mean URF values for the groups ($p < 0.01$). The mean URF value for the composite resin group was statistically higher than those for the other filling material groups respectively ($p < 0.05$).
Conclusions: The retention of castings cemented to straight implant abutments using non-eugenol temporary cement may be influenced by the screw access channel filling material.

Keywords: Implant, abutment, uniaxial retention, screw access channel, cement.

Abbreviations and acronyms: ANOVA = analysis of variance; PTFE = polytetrafluoroethylene; PVS = polyvinyl siloxane; URF = uniaxial retentive force.

(Accepted for publication 22 April 2013.)

INTRODUCTION

During recent decades, prosthetic rehabilitation of edentulism with dental implants has become a scientifically well-documented and commonly established treatment modality. Implant-supported restorations often represent a better alternative than conventional treatment modalities for tooth replacement. The selection of the retention method, screw-retained or cement-retained, involves a complex and comprehensive decision including consideration of the many points.[1,2]

Cement-retained, implant-supported restorations offer several advantages over screw-retained restorations, including enhanced aesthetics, with the elimination of screw access holes; greater resistance to fracture; more stable occlusal contacts in the area of the screw access channel; shorter and fewer appointments for fabrication; and comparatively easy and cost-effective laboratory procedures.[3–6] However, in circumstances involving the existence of deep submucosal shoulders, failure to remove excess cement is a major disadvantage that may lead to inflammatory tissue responses and/or bone loss.[7] Modern implant systems have new designs, involving custom abutments, which position the cemented junction either slightly subgingivally or supragingivally, thus reducing complications.

Retention is a key factor for determining the clinical success of cement-retained implant-supported restorations.[5] The factors that influence the retention of cement-retained restorations have been well documented. Cement type, composition, variations in cement viscosity, film thickness, variations in the seating forces, the duration of the force applied, as well as the axial wall taper, diameter, height, surface area, and roughness of the abutments have been shown to impact the retention of implant-supported restorations.[8–10]

The fabrication procedure of implant supported restorations in many ways resembles the fabrication of tooth supported fixed partial restorations where the presence of a screw access channel is the major difference between a prepared natural tooth and an implant abutment onto which a crown may be cemented.

Materials such as cotton, gutta-percha, polyvinyl siloxane (PVS), auto-polymerizing acrylic resin, composite resin, temporary restorative fillings, and polytetrafluoroethylene (PTFE) tape, have been suggested for partial or complete filling of the screw access channels prior to cementation of the restoration.[11–13]

These materials cover the head of the abutment screw, but enable future clinical access to the screw if required. Subjective factors, such as the ease of manipulation, influence a clinician's preference of filling material.

The factors influencing the retention of dental restorations involving implant abutments have been thoroughly investigated in the literature.[5–8] Even though the screw access channel comprises a relatively smaller portion of the abutment in contact with the cement for short abutments, the screw access channel filling material may have an effect on retention. Therefore, comparison of the filling materials may have clinical relevance in terms of selection of the correct material.

A limited number of studies assessing the efficacy of screw access channel filling materials on retention have been performed on angled implant abutments.[14,15] However, the presence of a correlation between the different filling materials used with short straight abutments and their retention has not previously been investigated. The null hypothesis of this study was that varying screw access channel filling materials would not have a significant effect on the uniaxial retention force (URF) of castings cemented to short straight implant abutments.

MATERIALS AND METHODS

Ten regular platform, straight Esthetic Abutments (Brånemark System®, Nobel Biocare, Göteborg, Sweden) were attached to their implant replicas with a 35 Ncm torque by using a torque control device. Implant assemblies were mounted vertically into auto-polymerizing acrylic resin (Orthocryl 2000®; Dentarum, Pforzheim, Germany) blocks with a surveyor using a custom, prefabricated, stainless steel aligning tip inserted into the abutment screw access channels. The minimum abutment height for fabrication of a cement-retained implant supported crown has been reported to be 5 mm.[16] Aesthetic abutments were cut horizontally to a height of 5 mm with a wire electro-discharge machine (Sodick A500; Fine Sodick Mark XI EDW, Sodick, Japan) and the height of each abutment was calculated and verified using a measuring microscope (Model MM-11U; Nikon, Melville, NY, USA). The screw access opening of each abutment was filled with polyvinyl siloxane putty (Elite H-D; Zhermack, Rovigo, Italy). Two layers of die spacers (Peel-Away Die Spacer, J Morita, CA, USA) were applied to the abutments within 1 mm of the margin. A total of 50 wax patterns with occlusal attachment rings were fabricated. The wax patterns were sprued, invested, and cast in nickel chrome ceramic alloy (Delta Ceram, Tritech, Voerde, Germany). After divestment, inner and outer surfaces of the castings were airborne-particle-abraded with 50 μm aluminium oxide (Ivoclar® Vivadent, Amherst, New York, USA) and adjusted onto the individual implant abutments with a fit checker (Fit Checker White, GC America Inc., Alsip, IL, USA). Each casting was numbered for easy identification during testing and assigned to correspondingly numbered abutments. Fifty casting-abutment assemblies were randomly divided into five groups (n = 10), and in each group, the screw access channels of the abutments were filled with different materials. These materials and their compositions are listed in Table 1. One prefabricated cotton pellet (Cotton pellets 4.0, Roeko, Langenau, Germany) was placed into each abutment screw access channel and the remaining space in the channel was then completely filled with the selected material using a hand instrument within the contour of the abutment.

Weighed amounts of temporary non-eugenol cement (Temp Bond, Kerr Corp, CA, USA) were mixed, according to the manufacturer's recommendations, and applied to the fitting surface of the castings. Each casting was placed with finger pressure for five seconds. The specimens were then subjected to a 5 kg load for five minutes.[8,14,15] Excess cement was removed using a scaler. Mixing and cementing procedures were performed at room temperature (24 ± 2 °C) by the same investigator. Specimens were stored

Table 1. Screw access channel filling materials used in this study

Product	Material type	Manufacturer
Filtek Z 250	Universal restorative composite resin	3M ESPE, St Paul, MN, USA
Clip	Light curing temporary filling	Voco, Cuxhaven, Germany
Coltosol	Temporary filling material	Coltene,Whaledent, Switzerland
Elite H-D	Polyvinyl siloxane putty	Zhermack, Rovigo, Italy
PTFE tape	Polytetrafluoroethylene tape	Kanca Makine, Istanbul, Turkey

at 37 °C for 24 hours and thermal cycled for 5000 cycles, at 5–55 °C with a 30-second dwell time. After thermal cycling, each assembly was attached to a universal testing machine (Autograph AG-X, Shimadzu Corp., Kyoto, Japan) to apply a tensile force with a crosshead speed of 5 mm/min.[8,14,15] The mean URF values in Newtons were recorded. The modes of cement failures, either adhesive or cohesive were also evaluated.

During the assessment of the data obtained in the study, SPSS (SPSS, Chicago, IL, USA) for Windows, version 15.0, was used for statistical analysis. One-way analysis of variance (ANOVA) was used to investigate the intergroup comparisons of parameters without normal distributions and the Tukey's HSD test was used to determine the group causing the difference. Significance was evaluated at a level of $p < 0.05$.

RESULTS

The mean URF values related for the five different filling materials are shown in Table 2. One-way ANOVA showed there were statistically significant differences between the mean URF values for the various groups ($p < 0.01$) (Table 2). The mean URF value of the Filtek Z 250 group was statistically higher than those for the Clip, Coltosol, Elite H-D and PTFE tape groups respectively ($p < 0.05$) (Fig. 1). The Clip group presented statistically higher values than the Elite H-D group ($p < 0.01$), and the difference between the Clip and Coltosol groups was statistically insignificant ($p > 0.05$) (Table 3). The Coltosol group presented a statistically higher URF value than the PTFE tape group ($p < 0.01$). A statistical difference was not observed between the mean URF values for the Elite H-D and PTFE tape groups ($p > 0.05$) (Table 3). The cement failure occured adhesively at the temporary cement-titanium abutment interface for 83% of the implant-casting assemblies. Cement was found mostly on the fitting surface of the castings, while for Filtek Z 250, Clip and Coltosol groups the temporary cement had adhered to the filling material surfaces. For Elite H-D and PTFE tape groups, cement residue was found mostly on the fitting surface of the castings and very little on the filling material surfaces.

Table 2. Mean uniaxial retentive force (URF) values for the different filling materials

Material	URF (Newton)	p
	Mean ± SD	
Filtek Z 250	118.51 ± 21.65	**0.001****
Clip	96.59 ± 15.68	
Coltosol	74.94 ± 24.08	
Elite H-D	53.84 ± 9.57	
PTFE tape	45.12 ± 11.46	

One-way ANOVA test ** $p < 0.01$.

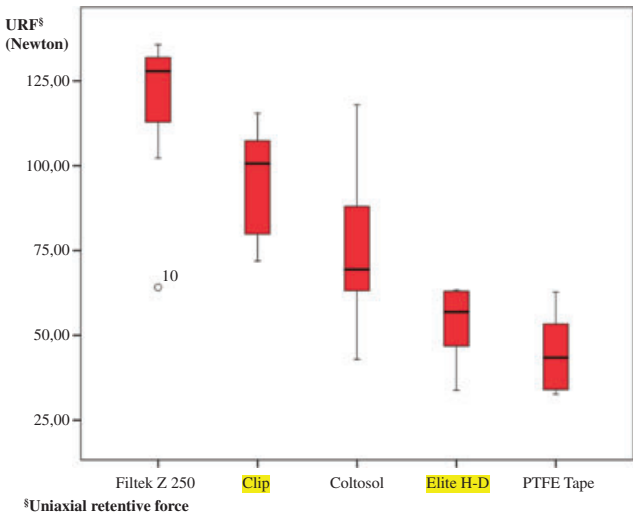

Fig. 1 Graphic presentation of median uniaxial retentive force values for different filling material groups.

Table 3. *Post hoc* test results

Material	p
Filtek Z 250 / Clip	0.050*
Filtek Z 250 / Coltosol	0.001**
Filtek Z 250 / Elite H-D	0.001**
Filtek Z 250 / PTFE tape	0.001**
Clip / Coltosol	0.058
Clip / Elite H-D	0.001**
Clip / PTFE tape	0.001**
Coltosol / Elite H-D	0.068
Coltosol / PTFE tape	0.003**
Elite H-D / PTFE tape	0.796

Tukey HSD Test *$p < 0.05$ **$p < 0.01$.

DISCUSSION

The null hypothesis of this study stated that varying the screw access channel filling materials would not have a significant effect on the mean URF values of the castings cemented to short implant abutments; the null hypothesis was rejected. Varying the screw access channel filling materials had significant effects on the URF values of the cement-retained, implant-supported restorations. The mean URF values of the studied materials were ordered as follows: Filtek Z 250 > Clip > Coltosol > Elite H-D > PTFE tape.

It has been reported that various materials have been used to fill the screw access channels of the abutments of cement-retained or screw-retained implant-supported restorations.[11–13] In the present study, the most retentive filling material, a composite resin (Filtek Z 250), is easy to manipulate but presents a risk of damaging the head of the abutment screw during removal.

PTFE tape, which presented the lowest URF value, is a relatively new material that has been used in dentistry as a liner for trial seating; for easy removal of intracoronally retained restorations prior to cementation; to repair abutment teeth under pre-existing crowns; as a block-out material for the connection of the locator and ball attachment components; and as a matrix to prevent etching and/or bonding of adjacent teeth.[11,17,18] PTFE is also a promising material for use in filling screw access channels to protect the head of the abutment screw in implant-supported prostheses, allowing easy manipulation as well as removal when required.

Cement-retained, implant-supported restorations offer better aesthetic results with the elimination of screw access holes and also allow the use of standard fixed partial prosthetic procedures in most situations. On the other hand, retrievability is a major drawback for the use of cement-retained restorations.[7] Nevertheless, although the screw-retained crown is retrievable, removing a well-fitting, cement-retained restoration when a complication occurs, can be a challenge, regardless of the cements used.

Although not a clear assumption, if retrievability is a major concern and the retentive form of the abutment is satisfactory, removal of a temporarily cemented restoration may be easier when the screw access channels are filled with Elite H-D or PTFE tape.

In the present study, the shortest abutment height, 5 mm, indicated for the fabrication of a cement-retained, implant-supported crown was selected.[16] The present research hypothesis was to evaluate the potential effect of the screw access channel filling material on retention, where the retentive form was compromised due to the minimum abutment height. The results of this study suggest that filling the screw access channel with Filtek Z 250 or Clip prior to temporary cementation may contribute to retention when the retentive form of the abutment is compromised.

After decementation, the modes of cement failure were recorded. The non-eugenol temporary cement was mostly found adherent to the filling material surfaces in the Filtek Z 250 and Clip groups. This result is similar to the results of a previous study.[14] In that study, the effect of the screw hole filling method on the retention of implant-supported crowns, cemented on 15° angled abutments, with non-eugenol temporary cement, was investigated. That study also reported that the bond strength was greatly reduced when composite core samples were cemented with eugenol temporary cement, to cast crowns where the eugenol, a phenol derivative, reacted with free radicals and thereby inhibited the polymerization of the resin system.[18,19] In the present study, for the Coltosol, Elite H-D, and PTFE tape groups, cement was not found to be adherent to the filling material surfaces. In accordance with Chu *et al.*,[14] the temporary cement adhered to the relatively rougher surfaces of the castings with no cement found on the prefabricated, polished, titanium abutment surfaces.

PVS impression materials are based on the inherently hydrophobic polydimethyl siloxane polymers.[19] Takahashi and Finger demonstrated that in order to increase the relative affinity of a liquid for a PVS impression material, an extrinsic surfactant should be applied before pouring. PTFE is also a high-molecular-weight, hydrophobic compound, consisting of carbon and fluorine.[20] Neither water nor water-containing substances wet PTFE, as fluorocarbons demonstrate dispersion forces due to the high electronegativity of fluorine.[17] The lowest URFs of Elite H-D and PTFE tape, may be attributed to the incompatibility of the water-containing temporary cement and the hydrophobic nature of these materials.

In the present study, factors such as cement type, axial wall taper, diameter, height and surface area of the abutments were standardized in order to evaluate only the effect of the filling materials on retention. The size of the screw access channel is smaller than the axial surface of the abutment, in contact with the cement and thus the contribution of this smaller area to the retention may be assumed to be negligible for unprepared standard height straight abutments. However, for shorter abutments, the effect of the screw access channel filling material on retention should be taken into consideration as increases occur in the relative ratio of the screw access channel area to the axial abutment surface area. In agreement with this assumption, the results of the present study revealed that different filling materials may affect the URF values of implant-supported restorations cemented on short straight abutments. Therefore, a more retentive filling material may be preferred for temporary cementation.

There are a number of limitations in this study. The effect of the filling materials was investigated under circumstances involving only one type of temporary cement, with the same abutment height and platform size. Another drawback of the study is the use of URF for evaluation of decementation. In a clinical situation, restorations in the oral environment are subjected to additional functional or parafunctional forces that may also contribute to crown decementation. Most luting cements, except the resin based ones, are prone to tensile failure due to brittle structure.[21] It has been reported that laterally directed forces may be more destructive to cement that is prone to tensile failure.[22] The uniaxial retention test procedure used in the present study was planned to minimize off-axis forces which could vary the cement failure load and account for some of the scatter recorded. Also, the tensile test was used in our study to allow comparisons with previous studies.

The influence of additional factors, such as cement type, composition, variations in cement viscosity, film thickness, as well as abutment characteristics, including axial wall taper, diameter, height, surface area, and roughness were not investigated in this study. Therefore, further clinical studies are needed to confirm our results by comparing more luting cements, varying abutment properties, and imitating the intraoral conditions with improved test methods.

CONCLUSIONS

Within the limitations of this study, the following conclusions were drawn: (1) The material used to fill the screw access channels of the short straight abutments may have an effect on the retention of temporarily cemented implant-supported restorations; (2) Removal of the temporarily cemented implant-supported restorations may be easier when the screw access channels are filled with PVS or PTFE; (3) Filling the screw access channel with Filtek Z 250 or Clip may contribute to retention of temporarily cemented restorations where the retentive form of the abutment is compromised.

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