Dental Research Journal

Original Article

The effect of different methods of cleansing temporary cement (with and without eugenol) on the final bond strength of implant-supported zirconia copings after final cementation: An *in vitro* study

Farshad Bajoghli[1], Amirhossein Fathi[2], Behnaz Ebadian[1], Mohammad Jowkar[3], Mahmoud Sabouhi[2]

[1]Department of Prosthodontics, Dental Implants Research Center, Dental Research Institute, School of Dentistry, Isfahan University of Medical Sciences, [2]Department of Prosthodontics, Dental Materials Research Center, Dental Research Institute, School of Dentistry, Isfahan University of Medical Sciences, Isfahan, Iran, [3]Department of Prosthodontics, Dental Research Center, Dental Research Institute, Isfahan University of Medical Sciences, Isfahan, Iran

ABSTRACT

Background: The temporary cement remaining inside the dental prosthesis can act as a source of microbial colonization and contamination and decrease the final cement retention. Consequently, complete removal of temporary cement before permanent cementation is suggested. This study aimed to assess the effect of different cleaning methods for removing temporary cement on the tensile bond force (TBF) of permanently cemented implant-supported zirconia copings.

Materials and Methods: In this *in vitro* study fifty titanium abutments were screwed onto 50 analogs with 30 Ncm torque into in acrylic resin blocks. Each abutment was scanned separately, and 50 zirconia copings were designed and milled. Permanent resin cement was used to cement copings of control group (N = 10). Copings were divided into two temporary cementation types that in each group, two cleansing methods were used: Temp-S (temporary cement with eugenol and sandblasted after debonding), Samples of the control group were placed in the universal testing machine, and the TBF values were recorded. Samples of the test groups after debonding and cleaning the abutments were subjected to cement with permanent resin cement, aging, and removing. Levene test, two-way analysis of variance (ANOVA), and Tamhane post hoc tests were applied. $\alpha = 0.05$.

Results: The highest and lowest TBF values were found for the TempNE-SU (554.7 ± 31.5 N) and Temp-S (492.2 ± 48 N) groups, respectively. The two groups of isopropyl alcohol baths in ultrasonics in combination with sandblasting showed statistically higher TBF values than the other two groups that used only sandblasting ($P < 0.001$) and had similar values compared to the control group.

Conclusion: Sandblasting combined with immersion in an ultrasonic bath containing isopropyl alcohol resulted in statistically similar values to the values of cementation with resin cement from the beginning. However, cleaning the inside of the copings only by sandblasting method reduced the values of the final retention force in comparison to cement with permanent resin cement from the beginning.

Key Words: Cleaning methods, permanently cemented implant, temporary cement removal, tensile bond force, zirconia

Received: 05-Aug-2022
Revised: 08-Sep-2022
Accepted: 17-Dec-2022
Published: 14-Feb-2023

Address of correspondence: Dr. Mohammad Jowkar, Department of Prosthodontics, School of Dentistry, Isfahan University of Medical Sciences, Hezar-Jarib Ave, Isfahan 8174673461, Iran.
E-mail: mohammad.jokar90@yahoo.com

Access this article online

Website: www.drj.ir
www.drjjournal.net
www.ncbi.nlm.nih.gov/pmc/journals/1480

How to cite this article: Bajoghli F, Fathi A, Ebadian B, Jowkar M, Sabouhi M, The effect of different methods of cleansing temporary cement (with and without eugenol) on the final bond strength of implant-supported zirconia copings after final cementation: An *in vitro* study. Dent Res J 2023;20:22.

INTRODUCTION

Various types of restorations are used to reinstate the shape and function of teeth, including intracoronal restorations, extracoronal restorations, fixed partial dentures, removable dentures, and implant-supported restorations.[1] Introduction of intraosseous dental implants has revolutionized the reconstruction of edentulous patients.[2,3] Prosthetic reconstruction by dental implants is stable treatment for edentulous patients and is considered a standard treatment in dentistry due to advances in technologies related to osseointegration.[2-4]

Knowing the factors that stabilize the hard and soft tissue around the implants in the long time is clinically important.[5] The retention of implant-supported restorations,[7] retention's components of prosthesis supported by implant,[8] material, geometry, length, type of surface roughness of abutment and implant veneer,[9-11] veneer cleaning method for re-cementing,[12] physical, chemical and bioactive properties of the adhesive cement, are among the most important factors.[13]

Fixed implant-supported dentures can be held in place by screw or cement.[14] Each type of gripping mechanism has advantages and disadvantages. Screw restorations are easily recoverable and have better repair capability and the ability to clean due to the ability to open these screw channels.[15] Additionally, there is a lower probability of preimplantitis due to the lack of cement stimulation around the implant tissues in this type of restoration.[16] The cemented implant prosthesis has the advantage of passive matching and occlusal integration.[14,17,18] Furthermore, implant restoration retrieval may be necessary in conditions such as cosmetic, mechanical, and biological problems in fixed implant prostheses.[19,20]

The choice of type of luting is an important factor in providing adequate retention of implant restorations maintained by cement.[21] Temporary cement are the most common luting materials used for these veneers. The cement should be strong enough to hold the prosthesis but, at the same time, should be weak enough to allow the dentists to remove the restoration comfortably and safely.[22] However, in some cases, such as insufficient abutment height, it may be necessary to select a luting agent with higher bond strength.[23] Moreover, after carefully assessing the health of the tissue and bone around the implants in cases of decementation of the restorations, physicians may prefer to replace the temporary cement with a permanent one.[22]

A cemented implant restoration sometimes needs to be re-cemented.[24] In these cases, permanent or temporary cement can be used to re-cement the repaired restorations.[24] Resin-based luting agents have been suggested in many cases because they provide high levels of trapping with low microleakage.[22] Temporary cement left inside the prosthesis can act as a source of contamination and reduce the final cement retention.[25,26] Additionally, this residual cement can prevent the micron roughness of the inner surface of the restoration and smooth it, thus reducing the final cement retention.[27] Furthermore, a temporary cement containing eugenol disrupts the resin cement bonding. This is due to the reduction of free radicals due to the action of eugenol and limits the polymerization of the resin.[28] As a result, complete removal of temporary cement before permanent cementation of the restoration is proposed. Different methods have been proposed for cleaning the inside of the restoration before its re-cementing. Residual cement extraction solutions,[29] hand tools such as curette,[30] ultrasonic bath with alcohol, sandblasting with alumina particles, and etching and burning of the remaining cement[31] are used for this purpose. However, most of these methods tested on tooth-supported restorations.[32]

The effect of different cleaning methods on the removal of eugenol-containing and eugenol-free temporary cement residues from implant-based zirconia prostheses and their role in the final tensile bond force (TBF) of these zirconia has not yet been investigated. The purpose of this study was to investigate the effect of different methods of cleaning zirconia copings cemented by two types of temporary cement (eugenol and noneugenol) on the removing force of the copings.

MATERIALS AND METHODS

Preparation of analogs and abutments

Fifty implant analogs (OPR, Zimmer, SwissPlus, Carlsbad, CA, USA) were vertically mounted in their own self-cure acrylic resin cylinder with size 10 mm × 20 mm. The alignment of analogs was confirmed by an expert surveyor. Abutment analog junction was placed 1 mm upper the resin cylinder. Fifty abutments (FMS, Zimmer, SwissPlus, θ 4.8, Carlsbad, CA, USA) with 7 mm height were screwed onto the analogs with a 30 Ncm torque force through a calibrated prosthetic torque wrench (Zimmer Dental, Carlsbad, CA, USA).

Copings preparation

Abutments were scanned separately. A computer-aided design/computer-aided manufacturing (CAD/CAM) device (Amann Girrbach, North America, Charlotte, USA) with a 30 µm space for the luting agent was used to fabricate 50 zirconia copings (Kerox, Sóskút, Hungary). Copings were designed with an occlusal loop. Loops were drilled in order to prepare adequate grip in universal testing machine tensile test. Stereomicroscope (×4 magnifications) was applied to assess the marginal fits of coping. Copings with unsuitable fit were excluded from the test. An ultrasonic bath containing ethanol 96% (5 min at 30°C) was used for cleaning all copings and abutments. After that, copings and abutments were washed by distilled water and dried. Teflon was used to fill the screw access of the abutments.

In vitro conditions

The 50 copings were divided into four experimental groups ($N = 40$) and a control group [$N = 10$, Table 1].

The manufactures guidelines were applied to cemented control copings using Panavia SA luting plus (Kuraray, Kurashiki, Japan). Forty copings of the test groups were resin cemented (Panavia SA luting plus, Kuraray, Kurashiki, Japan). The other four groups were cemented using the temporary cement with and without eugenol (TempBond and TempBond NE, Kerr, Hamm, Germany) (Temp and TempNE groups in first cementation process). For this purpose, the internal walls of copings were covered with cement using a brush and pushed down by pressure hand for 10 s. Guidelines of the American Dental Association specification (No. 96) were then applied to loaded samples by a 5 kg force for 10 min. Samples were soaked in distilled water (24 h at 37°). Prepared samples were tested by 5000 thermal cycles (5°C–55°C, 30 s dwell time) to pretend the oral condition. Copings were tested by a universal testing machine (Type LFML, Walter + Bai AG, Löhningen, Switzerland) to assess the TBF.[33] Abutment's internal surface was cleaned using a dental excavator mechanically. Additionally, the internal surfaces were next cleaned by CleanPolish paste (Kerr, Hamm, Germany) and dental polishing paste (Kerr, Hamm, Germany) by prophy brushes for 1 min. Following the copings cleansing process, samples cementing with permanent resin cement and aging were done. Then in Newton units, the removing force of the copings was measured.

Preparation of Temp-S and TempNE-S groups

Sandblast with 50 µm aluminum oxide particles under 1.5 bar pressure at distance of 1 cm at 45° for 15 s, rinse with isopropyl alcohol 70% for 30 s, and then wash with water for 30 s and dry with air.

Preparation of Temp-SU and TempNE-SU groups

Sandblast with 50 µm particles of aluminum oxide under 1.5 bar pressure at distance of 1 cm at 45° for 15 s, rinse with isopropyl alcohol 70% for 30 s, then

Table 1: Groups of copings in the present study

First cementation	After debonding	*n*	Cleaning method
Temp	Temp-S	10	Temporary cement group (first cementation) with eugenol, sandblasted with 50 µm aluminum oxide particles (1.5 bar, 15 s, applied at a distance of 1 cm and 45° to the nozzle), rinse with isopropyl alcohol for 30 s, washed with distilled water for the 30 s and dried after debonding
	Temp-SU	10	Temporary cement group (first cementation) with eugenol, sandblasted with 50 µm aluminum oxide particles (1.5 bar, 15 s, applied at a distance of 1 cm and 45° to the nozzle), rinse with isopropyl alcohol for 30 s, washed with distilled water for the 30 s, dried and put in ultrasonic bath with isopropyl alcohol 70% at 30°C for 15 min, washed with distilled water for 30 s and dried after debonding
Temp (NE)	TempNE-S	10	Temporary cement group (first cementation) without eugenol sandblasted with 50 µm aluminum oxide particles (1.5 bar, 15 s, applied at a distance of 1 cm and 45° to the nozzle), rinse with isopropyl alcohol for 30 s, washed with distilled water for the 30 s and dried after debonding
	TempNE-SU	10	Temporary cement group (first cementation) without eugenol, sandblasted with 50 µm aluminum oxide particles (1.5 bar, 15 s, applied at a distance of 1 cm and 45° to the nozzle), rinse with isopropyl alcohol for 30 s, washed with distilled water for the 30 s, dried and put in ultrasonic bath with isopropyl alcohol 70% at 30°C for 15 min, washed with distilled water for 30 s and dried after debonding
Control		10	Permanent resin cement (Panavia SA Luting plus, Kuraray, Kurashiki, Japan) was used

Temp: Temporary cement group with eugenol in first cementation, Temp-S: Temporary cement group with eugenol which sandblasted after debonding and re-cementation with resin cement, Temp-SU: Temporary cement group with eugenol which sandblasted and put in ultrasonic bath with isopropyl alcohol after debonding and re-cementation with resin cement, TempNE-S: Temporary cement group without eugenol which sandblasted after debonding and re-cementation with resin cement, TempNE-SU: Temporary cement group with eugenol which sandblasted and put in ultrasonic bath with isopropyl alcohol after debonding and re-cementation with resin cement rinse with water for 30 s and place the copings in an ultrasonic bath (isopropyl alcohol 70% 30°C, 15 min), and then rinse with water for 30 s and air dry.

Data analysis

For statistical analysis, Levene test, two-way analysis of variance (ANOVA), and Tamhane *post hoc* tests were applied. A significance level of $\alpha = 0.05$ was used in the measurements. SPSS statistical package (IBM SPSS Statistics, v24; IBM Corp, Armonk, NY, USA) was used in all tests.

RESULTS

Table 2 shows the mean ± standard deviation of TBF (N) of the experimental groups. The highest and lowest TBF values were found for the TempNE-SU (554.7 ± 31.5 N) and TempNE (58 ± 7 N) groups.

The Levene test used to analyze the homogeneity of the collected data showed no significant differences between the type of temporary cement and the method of treatment variances ($P = 0.37$) [Table 3]. Hence, it was appropriate to use a two-way ANOVA test, which showed a significant difference ($P < 001$) between the two temporary cement that were used [Table 3].

Tamhane *post hoc* test was used for pair-wise comparison of the study groups [Table 4]. There were no significant differences in TBF values between the groups where isopropyl alcohol was used in ultrasonic bath (Temp-SU and TempNE-SU). Similarly, there were no significant differences in TBF values between the groups where only sandblast was used (Temp-S and TempNE-SU). Two groups of isopropyl alcohol in ultrasonic bath combined with sandblast showed significantly higher TBF values than two groups which only sandblast was used. The control group (luted with resin cement) showed a statistically similar TBF value in comparison to groups of ultrasonic bath combined with sandblast treatment, and higher values than groups which only sandblast was used. According to the temporary cement of first cementation, the TempNE group showed significantly lower values than the Temp group. The detailed TBF values of all the studied groups are presented in Table 4.

DISCUSSION

The aim of this study was to investigate the effect of different methods of cleaning zirconia copings cemented by two types of temporary cement (eugenol and noneugenol) on the force of removing copings after re-cementing with permanent cement to titanium implant abutment. Findings showed that the mean value of TBF in eugenol temporary cement was 122 ± 21 N, which was statistically higher than the values of eugenol temporary cement (58 ± 7 N). In both eugenol and noneugenol temporary cement,

Table 2: Mean±standard deviation of tensile bond force (*n*) of the experimental groups

experimental group	Mean±SD	95% CI for mean		Minimum	Maximum
		Lower bound	Upper bound		
Temp	122.1^{b}±21	112.3	132	90.9	168.4
TempNE	58.2^{a}±7.3	54.8	61.6	48.8	71.6
C	551^{d}±61.8	506.8	595.2	453.3	660.8
Temp-S	492.2^{c}±48.8	457.3	527.1	420.4	574.7
Temp-SU	549.1^{d}±35.9	523.4	574.8	502.1	607.8
TempNE-S	503.8^{c}±34.8	479	528.7	432.7	550.2
TempNE-SU	554.7^{d}±31.5	532.2	577.3	499.7	598.2

Superscripted lower case letters were used to indicate means that are the same. Temp: Temporary cement group with eugenol in first cementation, TempNE: Temporary cement group without eugenol in first cementation, C: Control (Panavia group), Temp-S: Temporary cement group with eugenol which sandblasted after debonding and re-cementation with resin cement, Temp-SU: Temporary cement group with eugenol which sandblasted and put in ultrasonic bath with isopropyl alcohol after debonding and re-cementation with resin cement, TempNE-S: Temporary cement group without eugenol which sandblasted after debonding and re-cementation with resin cement, TempNE-SU: Temporary cement group with eugenol which sandblasted and put in ultrasonic bath with isopropyl alcohol after debonding and re-cementation with resin cement. SD: Standard deviation, CI: Confidence interval

Table 3: Two-way analysis of variance results of different temporary cement and treatment methods on tensile bond force

Intervention	Type III sum of squares	df	Mean square	*F*	Significance
Cement	746.32	1	746.32	0.51	0.48
Treatment	29,062.88	1	29,062.88	19.79	0.00
Cement×treatment	90.6	2	227,530.23	0.06	0.81

Table 4: Pair-wise comparison between study groups (Tamhane *post hoc* test)

Groups	TempNE	C	Temp-S	Temp-SU	TempNE-S	TempNE-SU
Temp	0.00	0.00	0.00	0.00	0.00	0.00
Tem NE	-	0.00	0.00	0.00	0.00	0.00
C	-	-	0.004	1.00	0.041	1.00
Temp-S	-	-	-	0.01	0.99	0.002
Temp-SU	-	-	-	-	0.06	1.00
TempNE-S	-	-	-	-	-	0.021

Temp: Temporary cement group with eugenol in first cementation, TempNE: Temporary cement group without eugenol in first cementation, C: Control (Panavia group), Temp-S: Temporary cement group with eugenol which sandblasted after debonding and re-cementation with resin cement, Temp-SU: Temporary cement group with eugenol which sandblasted and put in ultrasonic bath with isopropyl alcohol after debonding and re-cementation with resin cement, TempNE-S: Temporary cement group without eugenol which sandblasted after debonding and re-cementation with resin cement, TempNE-SU: Temporary cement group with eugenol which sandblasted and put in ultrasonic bath with isopropyl alcohol after debonding and re-cementation with resin cement

the groups treated with sandblasting and isopropyl alcohol bath in ultrasonic had higher TBF values than the group treated with sandblasting alone. The values of TBF in temporary cement with eugenol and without eugenol in the same cleaning method were statistically similar.

TBF values in various studies for eugenol-free temporary cement were in the range of 23–85 N,[12,34,35] for temporary cement with eugenol were in the range of 115–164 N,[30] and for permanent resin cement were reported in the range of 314–820 N,[24,30,36] which was consistent with the TBF values of the present study.

Scarce studies have been conducted on this regard. Keum and Shin[37] reported that plastic curettes were not operative in improving the TBF of the permanently cemented prosthesis. Nevertheless, the use of rubber cups with pumice or sandblasting enhanced the TBS. In a survey of Song *et al*.,[1] increased TBF of zinc phosphate-coated copings was reported in the use of sandblasting.

Higher amounts of TBF in the sandblasted and alcohol bath in the ultrasonic group than in the control group may be due to the fact that the alcohol bath has the ability to remove the remaining eugenol completely and sandblasting may cause porosity in the inner surface of the copings and thus increase the amount of TBF. After that, the highest values of TBF belonged to the sandblast and ultrasonic groups when temporary TempBond cement with eugenol was used; these results were consistent with the results of the above studies.[38] As a result of sandblasting with aluminum oxide particles, surfaces may become rough and irregular, increasing the possibility of cement sticking and increasing the final TBF.[39]

Although the findings of the present study and previous researches[1,40] were somewhat similar, there were some significant differences in methodology. All copings in the present study were designed and prepared by CAD/CAM technology to eliminate any possible bias or carelessness. A new change that had not been made in previous studies was the sandblasting process described and the use of an ultrasonic bath with isopropyl alcohol simultaneously.

There has been a controversial issue about the possibility of negative interactions between resin cement and eugenol-containing cement from the past to the present. Ribeiro *et al*.[41] investigated dentin residual eugenol on the final bond strength of total etched and self-etched resin cement after standard cleaning processes. They found that eugenol residue significantly reduced the bond strength of indirect restorations bonded with resin cement. Similar findings have been obtained by Carvalho *et al*.[42] However, the effect of reducing the bond strength by eugenol was seen only in self-etched cement. In keeping with this, the findings of the present study were different from previous researches because the group that was cleaned by combined sandblasting and ultrasonic method, with or without eugenol temporary cement were not significantly different from control group contained PANAVIA™ resin cement. These findings could support the hypothesis that the combined cleaning method can neutralize the effect of eugenol, and the method of cleaning the remaining cement is a more important factor than whether the temporary cement has eugenol or not. Additionally, the present study was performed on titanium implant abutments and not natural teeth and dentin.

The results of the present study showed that the use of isopropyl alcohol bath in combination with sandblast is the best way to remove cement residues with or without eugenol and significantly increased the final cement retention. This finding was consistent with the study of de Oliveira *et al*.[43] who observed the effect of different cleaning protocols and materials on the bond strength of fiber post and root dentin. After testing a solution of saline, acetone, ethanol 70%, and isopropyl 70%, they found that in the group of alcohols, higher bond strength was obtained. Similar findings were obtained by Safari *et al*.[24] They investigated the role of abutment diameter, cement type, and re-cementation process on the final bond strength of low-code metal copings supported by implants. The result of their study showed that resin cement has the highest values of TBF and also increasing the diameter of the abutment caused an increase in the TBF. However, re-cementation with resin cement did not significantly change the TBF after the use of temporary cement containing eugenol.

Our study has certain limitations, including not examining abutments with different shapes, lengths, diameters and not investigating other methods of cleaning copings, and not investigating semi-permanent implants with resin cement which are recommended in future studies.

Cleaning of cemented zirconia copings with or without eugenol temporary cement by sandblasting with ultrasonic containing isopropyl alcohol produced a similar TBF to the control group, but the sandblasting method alone reduced the final cement retention values. The method of cleaning the inner surface of the copings was a more important factor in the final TBF of the copings compared to the initial temporary cement type.

Author contributions

Behnz Ebadian: Supervised the research, designed the research, contributed analysis tools, and wrote the paper. Mohammad Jowkar: Data collection, performed the analysis, and drafted the article. Farshad Bajoghli: Wrote the paper and data interpretation. Amirhossein Fathi: Data collection and wrote the paper. Mahmoud Sabouhi: Supervised the writing and critical revision of the article.

Data availability statement

Data are available whenever needed.

Acknowledgment

This study was supported by Isfahan University of Medical Sciences (grant no: 3400526). We wish to thank the Research Deputy of Isfahan University of Medical Sciences, Iran.

Financial support and sponsorship

Nil.

Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or nonfinancial in this article.

REFERENCES

1. Song MY, An H, Park EJ. The effect of temporary cement cleaning methods on the retention of crowns. J Prosthodont 2019;28:e210-5.
2. Raikar S, Talukdar P, Kumari S, Panda SK, Oommen VM, Prasad A. Factors affecting the survival rate of dental implants: A retrospective study. J Int Soc Prev Community Dent 2017;7:351-5.
3. Zanetti EM, Pascoletti G, Calì M, Bignardi C, Franceschini G. Clinical assessment of dental implant stability during follow-up: What is actually measured, and perspectives. Biosensors (Basel) 2018;8:68.
4. Wittneben JG, Joda T, Weber HP, Brägger U. Screw retained versus cement retained implant-supported fixed dental prosthesis. Periodontol 2000 2017;73:141-51.
5. Kim DD, Ghali GE. Dental implants in oral cancer reconstruction. Oral Maxillofac Surg Clin North Am 2011;23:337-45, vii.
6. Rosano G, Taschieri S, Del Fabbro M. Immediate postextraction implant placement using plasma rich in growth factors technology in maxillary premolar region: A new strategy for soft tissue management. J Oral Implantol 2013;39:98-102.
7. Bishti S, Tuna T, Agrawal G, Pich A, Wolfart S. Modified glass ionomer cement with "remove on demand" properties: An *in vitro* study. Dent J (Basel) 2017;5: 9.
8. Schierano G, Manzella C, Menicucci G, Parrotta A, Zanetti EM, Audenino AL. *In vitro* standardization of two different removal devices in cemented implant prosthesis. Clin Oral Implants Res 2016;27:1026-30.
9. Abrahamsson I, Berglundh T, Glantz PO, Lindhe J. The mucosal attachment at different abutments. An experimental study in dogs. J Clin Periodontol 1998;25:721-7.
10. Mehl C, Harder S, Wolfart M, Kern M, Wolfart S. Retrievability of implant-retained crowns following cementation. Clin Oral Implants Res 2008;19:1304-11.
11. Sahu N, Lakshmi N, Azhagarasan NS, Agnihotri Y, Rajan M, Hariharan R. Comparison of the effect of implant abutment surface modifications on retention of implant-supported restoration with a polymer based cement. J Clin Diagn Res 2014;8:239-42.
12. Rödiger M, Rinke S, Ehret-Kleinau F, Pohlmeyer F, Lange K, Bürgers R, *et al.* Evaluation of removal forces of implant-supported zirconia copings depending on abutment geometry, luting agent and cleaning method during re-cementation. J Adv Prosthodont 2014;6:233-40.
13. Güncü MB, Cakan U, Canay S. Comparison of 3 luting agents on retention of implant-supported crowns on 2 different abutments. Implant Dent 2011;20:349-53.
14. Romanos GE, Delgado-Ruiz R, Sculean A. Concepts for prevention of complications in implant therapy. Periodontol 2000 2019;81:7-17.

15. Kunt GE, Ceylan G, Yilmaz N, Kücük B. Luting agent effectiveness on implant crown retention. Int J Oral Implantol Clin Res 2011;2:7-11.
16. Brägger U, Karoussis I, Persson R, Pjetursson B, Salvi G, Lang N. Technical and biological complications/failures with single crowns and fixed partial dentures on implants: A 10-year prospective cohort study. Clin Oral Implants Res 2005;16:326-34.
17. Hamed MT, Abdullah Mously H, Khalid Alamoudi S, Hossam Hashem AB, Hussein Naguib G. A systematic review of screw versus cement-retained fixed implant supported reconstructions. Clin Cosmet Investig Dent 2020;12:9-16.
18. Davoudi A, Rismanchian M. Effects of modifying implant screw access channels on the amount of extruded excess cement and retention of cement-retained implant-supported dental prostheses: A systematic review. J Prosthet Dent 2019;121:52-8.
19. Addy LD, Bartley A, Hayes SJ. Crown and bridge disassembly – When, why and how. Dent Update. 2007;34(3):140-50.
20. Lugas AT, Terzini M, Zanetti EM, Schierano G, Manzella C, Baldi D, *et al. In vitro* simulation of dental implant bridges removal: influence of luting agent and abutments geometry on retrievability. Materials (Basel) 2020;13:2797.
21. Jain JK, Sethuraman R, Chauhan S, Javiya P, Srivastava S, Patel R, *et al.* Retention failures in cement- and screw-retained fixed restorations on dental implants in partially edentulous arches: A systematic review with meta-analysis. J Indian Prosthodont Soc 2018;18:201-11.
22. Almehmadi N, Kutkut A, Al-Sabbagh M. What is the best available luting agent for implant prosthesis? Dent Clin North Am 2019;63:531-45.
23. Gómez-Polo M, Ortega R, Gómez-Polo C, Celemin A, Del Rio Highsmith J. Factors affecting the decision to use cemented or screw-retained fixed implant-supported prostheses: A critical review. Int J Prosthodont 2018;31:43-54.
24. Safari S, Hosseini Ghavam F, Amini P, Yaghmaei K. Effects of abutment diameter, luting agent type, and re-cementation on the retention of implant-supported CAD/CAM metal copings over short abutments. J Adv Prosthodont 2018;10:1-7.
25. Grasso CA, Caluori DM, Goldstein GR, Hittelman E. *In vivo* evaluation of three cleansing techniques for prepared abutment teeth. J Prosthet Dent 2002;88:437-41.
26. Erkut S, Küçükesmen HC, Eminkahyagil N, Imirzalioglu P, Karabulut E. Influence of previous provisional cementation on the bond strength between two definitive resin-based luting and dentin bonding agents and human dentin. Oper Dent 2007;32:84-93.
27. Peutzfeldt A, Asmussen E. Influence of eugenol-containing temporary cement on efficacy of dentin-bonding systems. Eur J Oral Sci 1999;107:65-9.
28. Lingard GL, Davies EH, Von Fraunhofer JA. The interaction between lining materials and composite resin restorative materials. J Oral Rehabil 1981;8:121-9.
29. Farzin M, Torabi K, Ahangari AH, Derafshi R. Effect of abutment modification and cement type on retention of cement-retained implant supported crowns. J Dent (Tehran) 2014;11:256-62.
30. Ayad MF, Rosenstiel SF, Woelfel JB. The effect of recementation on crown retention. Int J Prosthodont 1998;11:177-82.
31. Ayad MF, Johnston WM, Rosenstiel SF. Influence of tooth preparation taper and cement type on recementation strength of complete metal crowns. J Prosthet Dent 2009;102:354-61.
32. Woody TL, Davis RD. The effect of eugenol-containing and eugenol-free temporary cements on microleakage in resin bonded restorations. Oper Dent 1992;17:175-80.
33. Ebadian B, Jowkar M, Davoudi A, Fathi A, Ziaei M, Berg E. The effect of different cleansing methods for removing temporary cement on the tensile bond force of permanently cemented implant-supported metal copings: An *in vitro* study. Clin Exp Dent Res 2022;8:1002-7.
34. Naumova EA, Roth F, Geis B, Baulig C, Arnold WH, Piwowarczyk A. Influence of luting materials on the retention of cemented implant-supported crowns: An *in vitro* study. Materials (Basel) 2018;11:1853.
35. Müller L, Rauch A, Reissmann DR, Schierz O. Impact of cement type and abutment height on pull-off force of zirconia reinforced lithium silicate crowns on titanium implant stock abutments: An *in vitro* study. BMC Oral Health 2021;21:592.
36. Ferro KJ, Morgano SM, Driscoll CF, Freilich MA, Guckes AD, Knoernschild KL, *et al.* The glossary of prosthodontic terms. J Prosthet Dent 2017;117:e1-e105.
37. Keum EC, Shin SY. A comparison of retentive strength of implant cement depending on various methods of removing provisional cement from implant abutment. J Adv Prosthodont 2013;5:234-40.
38. Gurbuz A, Inan O, Kaplan R, Ozturk AN. Effect of airborne-particle abrasion on retentive strength in overtapered fixed prosthodontic restorations. Quintessence Int 2008;39:e134-8.
39. Rismanchian M, Davoudi A, Shadmehr E. Effect of using nano and micro airborne abrasive particles on bond strength of implant abutment to prosthesis. Braz Dent J 2015;26:50-5.
40. Petrauskas A, Novaes Olivieri KA, Pupo YM, Berger G, Gonçalves Betiol EÁ. Influence of different resin cements and surface treatments on microshear bond strength of zirconia-based ceramics. J Conserv Dent 2018;21:198-204.
41. Ribeiro JC, Coelho PG, Janal MN, Silva NR, Monteiro AJ, Fernandes CA. The influence of temporary cements on dental adhesive systems for luting cementation. J Dent 2011;39:255-62.
42. Carvalho CN, de Oliveira Bauer JR, Loguercio AD, Reis A. Effect of ZOE temporary restoration on resin-dentin bond strength using different adhesive strategies. J Esthet Restor Dent 2007;19:144-52.
43. de Oliveira E, Cecchin D, Miyagaki DC, de Moura AL, Disarz A, Souza MA, *et al.* Effect of different protocols of eugenol removal on the bond strength between the fibre post and root dentin. Aust Endod J 2019;45:177-83.