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FULL PAPER

Effect of zinc phosphate and non-eugenol temporary dental cement on different modification of abutment in implant restoration

Shayan Ahmadi[a] |**Ali Torab**[b] |**Ramin Negahdari**[c,*]

[a]*Graduate Student of Prosthodontics, Department of Prosthodontics, Faculty of Dentistry, Tabriz University of Medical Science, Tabriz, Iran*

[b]*Assistant Professor, Department of Prosthodontics, Faculty of Dentistry, Tabriz University of Medical Science, Tabriz, Iran*

[c]*Associate Professor, Department of Prosthodontics, Faculty of Dentistry, Tabriz University of Medical Science, Tabriz, Iran*

***Corresponding Author:**
Ramin Negahdari
Email: ramin_n_dds@yahoo.com
Tel.: +984133353161

Fixed implant-dependent prostheses are one of the most common treatments in dentistry. The aim of this study was to test the impact of modifications of the implant-abutment body on the retention rate of the cemented implant prostheses. For this purpose, sixty-four DIO implants in 8 groups were used. The retention levels of permanent cements were greater than that of temporary cements. The highest retention rate was reported in the group of permanent cements in sandblast implants and then in double-vented and single-vented abutments and finally in the control group, but in the group of temporary cements, the lowest rate of retention was reported in double-vented and single-vented abutments and finally in the control group. In the group of temporary cements, like permanent partners, sandblast abutments had the highest retention. By creating architectural improvements in the body of the abutments, in addition to getting an appropriate amount of retention close to permanent cement clinically, the benefits of temporary cements such as their higher solubility and the avoidance of the possible dangers of the residual cements could be exploited.

KEYWORDS

Implant; retention rate; cemented implant prostheses.

Introduction

The success of oral therapy for implant healing is influenced by the osseointegration of the implant fixture as well as keeping the integrity of the connection between the prosthetic building and the fixture [5,11,21]. One of the most common treatments in dentistry is fixed implant-dependent prostheses. Dental prostheses are attached to the implant by the abutment in the following two ways: Screwed or cemented [18]. Each of the mentioned methods has their own benefits and drawbacks. Among the benefits of screwing methods are the flexibility of the prosthesis fastening process, the capability of retrieval and the adequate retention in cases of restricted interocclusal space. The benefits of cemented prostheses include simplicity of splintering, ease of sitting patio prosthesis, the resemblance of measures with natural dental veneers, reduction of fracture risk of sections, reduction of fracturing of porcelain, enhanced elegance, and simpler management of occlusion, lower expense and duration of therapy relative to screwed procedures [18, 25]. Restoration of the aspiration, increased bone erosion around the implant, cracking of the prosthesis, trauma through the front teeth, accumulation of food and microorganisms and, as a result, impaired breathing and soft tissue reaction are some of the issues caused by the increment of these restorations, despite the stated benefits [9]. Restoration is the elimination except for injury to the abutment, restoration and tissues around the implant or so-called retrieval capability in addition to providing adequate resistance to loosening, including the advantages of cement retention in such restorations in the best conditions [3]. Therefore, one of the success factors in treatment is the retention of implant-supported restorations [19]. Temporary cements are widely used for cemented implant-dependent restorations to provide retrieval capabilities. The reason why distinctive techniques are used to extend the retention is that the use of this type of cement in some cases reduces the retention and increases the possibility of restoration uncemented [9]. On the other hand, implant osteointegration may be damaged by cements with higher retention capacity during the removal of the restoration [19]. Factors affecting retention in cement restorations are classified into 3 groups: 1) preparation methods of the abutment (degree of convergence, height and level of preparation), 2) Casting (matching of veneer and abutment, the effect of predetermined vents in casting), and 3) Cement (type and viscosity) [7]. Each of the aforementioned strategies has its benefits and drawbacks. The findings of numerous studies indicate that the variables that improve retention include height rise, tipper decrease and abutment increase [7]. One approach to improve retention is to establish a box or groove [7]. Another strategy that can enhance the retention rate is to change the form of cement, including the use of stable cements, although when removing the restoration, the use of high retention cements can trigger harm to the osteointegration of the implants [19]. However, the findings of several experiments indicate that high-retention cements, such as methacrylates, are a safe site for more bacterial colonization [20]. The possibility of residual cement and its lack of complete removal may be thought of as a part of the disadvantages of using permanent cements. Although there is scarce proof for the foremost acceptable kind of cement and therefore the behavior of temporary cement within the long-standing time, any reports advocate the use of temporary cement in optimal tipping conditions and high abutment walls [7]. Another technique that has been mentioned in some studies could be an amendment within the style of the abutment body [14,25]. Creating a vent or groove are differing kinds of changes within the geometric style of the body of the abutments. The changes created on the body of the abutment act just like the interior vent as well as reducing the surplus cement, will improve the subsidence of the veneer [20, 25]. In addition, these changes will enhance the veneer's retention capacity [4]. Various biological conditions increase the susceptibility of the tissues around the implant to cement as opposed to normal teeth [26]. The results of a cohort study showed that microorganism colonization on excess cement directly causes 80% of diseases within the soft tissues around the implant [25]. In addition, several reports have already shown that throughout surgical explorative interventions, in 81% of all BOP-positive implants and saccular secretions, excess cement around the implant is found [13]. Removing the veneer in emergencies may be challenged by the use of higher retention cements [13]. According to previously conducted investigations, thorough research on the effect of improvements inside the implant body and an analysis of cementing with temporary and permanent cement retention levels across the implant crowns has not been carried out yet, which is why the purpose of this study was to explore a number of assorted changes in the amount of retention in cemented implant prostheses [20,25].

The key purpose of this analysis was to examine the improvement in the retention of crowns by temporary cements by making different modifications in the basement in order to increase the optimum retention and capability of retrieval of the crown and conjointly to minimize the difficulties and potential problems of the residual cement in the cemented implant crowns owing to the increase solubility of temporary cement relative to permanent cements.

Experimental phase

Sixty-four DIO implants (DIO Implant Co, Ltd., Busan, Republic of Korea) with a length of 5.5 mm and a diameter of 4.5 mm and a gingival height of 1 mm were used. The abutments were connected to the fixture analogs of the identical device by means of a wrench with a DIO system and a torque of 25 N/cm2 and vertically installed to self-curing acrylic blocks (Acropars, Marlic, Tehran, Iran) with a diameter of 2.5 cm and a height of 3 cm. The improvements made to the body of the abutment were produced via Turn MachineTN50BR (MST Co. Tabriz, Iran) (Figure 1).

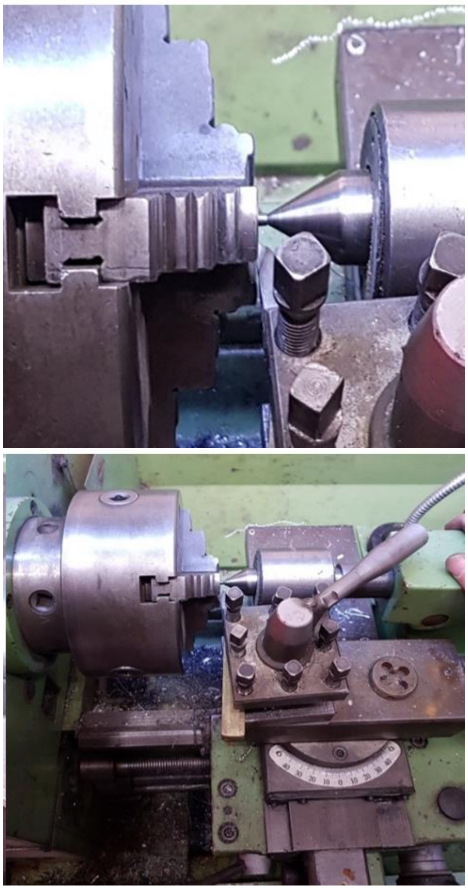

FIGURE 1 Changing the body of the abutment by the Turning Machine TN50BR

Sixty-four copings were made using the CAD technique to unify the samples. Before modifying using a 3D Maestro scanner, an abutment in this process was scanned (AGE, Solutions S.R,L, Italy) (Figure 2) and the coping was designed using EXO CAD software with 50 micrometers of cement space. (Figure 3). Using a 3D printer (Prodent 3D Printer, Bonyan Mechatronic Co., Iran) and Light Cure resin (Freeprint Cast, DETAX GmbH & Co. KG, Ettlingen, Germany), the initial coping was then printed. Before casting, a loop-like attachment was then supplemented to the occlusal surface of each coping.

FIGURE 2 Resin template rendered by 3D printer (right) and final casting coping (left)

FIGURE 3 Set of abutment and analog mounted in acrylic block (right) and occlusion of the access hole of the abutment screw using temporary filler (left)

The consistency and integrity of the wax pattern was checked after the above process and waxed up in the absence of defects and then invested in phosphate bonded substances (ERNST HINRICHS, GmbH, Germany); it was finally cast using Base Metal alloy (Sankin, nonberyllium, Dentsply, Tokyo, Japan). To examine the settling on the abutment, the casted copings after cleaning with steam (Pro-craft II steamer cleaner, Ivoclar Vivaden, Amherst, NY) were evaluated with a microscope (Nikon, Japan) by a magnification of 3.5 times and the ruggedness of the inner surface of the casting was removed using a 1/2 milling cutter. Using the disclosing substance, the match of the castings on the abutment (Alignment checker, GC Corporation, Tokyo, Japan) was assessed and the intervention areas were again eliminated by a milling cutter. Settlement-incompatible copings were excluded from the study. Acrylic blocks were a good position to mount the abutment assembly and the corresponding analog to facilitate the continuation of the work process. The occlusal surface associated with the cavity of abutment screw access was filled to 3 mm with temporary filler, Coltosol (Coltène/Whaledent AG) prior to cementation (Figure 3).

Following preparation, the samples were randomly divided into 8 groups of 8 participants each and therefore the following modifications were applied:

Groups 1 and 2: Using straight fissure carbide milling of Tizkavan company (CB21 Regular burs, 500.204.107.006.010, straight fissure, Germany), a horizontal vent with a diameter of 1 mm and 1 mm below the occlusal edge of the abutment was formed and this modification was rendered using Hand-piece fixed.

Groups 3 and 4: Using straight fissure carbide milling of D + Z company (CB21 Regular burs, 500.204.107.006.010, straight fissure, Germany), two vents with a diameter of 1 mm with an angle of 180 degrees to each other and one millimeter below the occlusal edge of the abutment was created and this modification was rendered using Handpiece fixed.

Groups 5 and 6: Sandblasting the surface of the abutment was carried out using alumina oxide particles with a diameter of 50 µm (Korox 50, Bego) with a pressure of 3 bars for 10 seconds at a distance of 10 mm and then eluted with water spray for 30 seconds and was dried by oil-free air spray.

Groups 7 and 8: control group (No change in abutment's original shape).

A vertical marker with a length of 5 mm was mounted on the outer surface of the copings to promote and monitor the placement of the copings on the abutments during the next phases and then the lower area of the margin of the abutment was marked with a fine liner.

To simulate the clinical condition after applying the mentioned changes, the occlusal surface of the cavity of the abutment screw access was filled with 3 mm by temporary filler substances, Coltosol (Coltène /

Whaledent AG) prior to cementing the copings on the abutment (this area itself acts as a place for cement accumulation). Then temporary cement, Temp Bond NE cement (Kerr Corporation, Romulus, Michigan, USA) and permanent zinc phosphate cement (Hoffmann dental manufacture GmbH, Cologne, Germany) were used for cementation. Then, 1.5 g of powder with 1 g of zinc phosphate cement liquid on dry and clean glass slab was mixed together at 20 °C to produce a uniform concentration according to the manufacturer's instructions. The powder was separated into 4 fractions including 1.8, 1.8, 1.4, 1.2 and the fractions were added into the weighted liquid beginning with their lowest quantity with the blowing of the spatula and the mixing process lasted 90 seconds. Reasonable concentration was achieved as the cement slowly moved from the spatula to the slab and 1.25 g of bis with 1.25 g of activator paste was combined for 30 seconds on a special and standard cement paper pad in order to generate temporary cement in compliance with the manufacturer's instructions. As for both methods, the inner surface of the copings was loaded with a brush and up to around 75% after mixing and then the copings were first mounted on the respective abutments by finger force and after that, 5 kg pressure was applied to them by Universal testing machine (Figure 4) (Universal testing machine, Zwick/Roell Z020, Ulm, Germany) and 10 minutes were allocated for cement setting. Through a catheter, the excess cement was drained before the final setting.

The specimens were then kept at 100% humidity and 37 °C for 24 hours. Following this step, the specimens were measured by a pull-out analysis at a crosshead speed of 0.5 mm/min with the universal test machine (Figure 5) and the force sufficient to separate the copings was calculated based on the Newton scale.

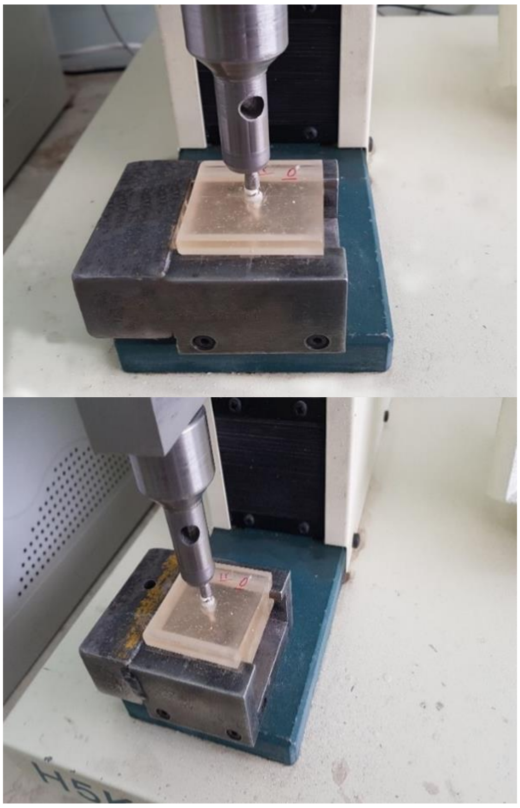

FIGURE 4 Loaded specimens in the universal test machine

FIGURE 5 Under tension specimens in the universal test machine

Statistical analysis

Using a descriptive statistical method (mean ± standard deviation), the data obtained from the test were analyzed. The normality of the data was evaluated by the Kolmogorov-Smirnov test (K-S test). Two Way Anova test or its nonparametric equivalent was used for data analysis. The SPSS 20 program was used for statistical analysis and the level of the significance of the test was considered P < 0.05. The number of sample sizes was calculated using the findings of the Farzin et al analysis and taking into consideration the first error rate a = 0.05 and test power b= 0.8. The number obtained was doubled in order to improve the precision of the analysis. Therefore, the sample size in each group was 8 and the sample size for this study was 64 due to the existence of 8 groups [23].

Results

For the experimental analysis, 64 samples were analyzed. The level of retention by the type of cement and the abutment in the implant prosthesis are displayed in Table 1.

TABLE 1 Retention rate in implant prostheses based on type of cement and of abutment

Cement/abutment	Temporary±SD	Permanent±SD
control	60.13±11.23	140±11.16
single-vented	58.35±10.18	170.91±12.02
double-vented	57.45±12.86	190.87±13.19
sandblast	145.70±18.12	465.31±19.21

The retention levels of permanent cements were greater than that of temporary cements. The highest retention rate was reported in the group of permanent cements in sandblast implants and then in double-vented and single-vented abutments and finally in the control group, but in the group of temporary cements, the lowest rate of retention was reported in double-vented and single-vented abutments and finally in the control group. In the group of temporary cements, like permanent partners, sandblast abutments had the highest retention. Table 2 and Figure 6 show the comparison of retention rates between cemented implant prostheses by Temp bond cement in sandblasted, single-vented, double-vented and control abutments. Only the amount of retention in sandblast abutments had a statistically significant difference with other groups (P <0.05) (Figure 1, Table 3).

TABLE 2 Retention levels in cemented implant prostheses with Temp bond cement in different abutments

Abutment	Mean±SD	Lowest	Highest
control	60.13±11.23	50.3	82
single-vented	58.35±10.18	45.7	73.2
double-vented	57.45±12.86	35.8	73
sandblast	145.70±18.12	122.3	170
total	80.40±40.38	35.8	170

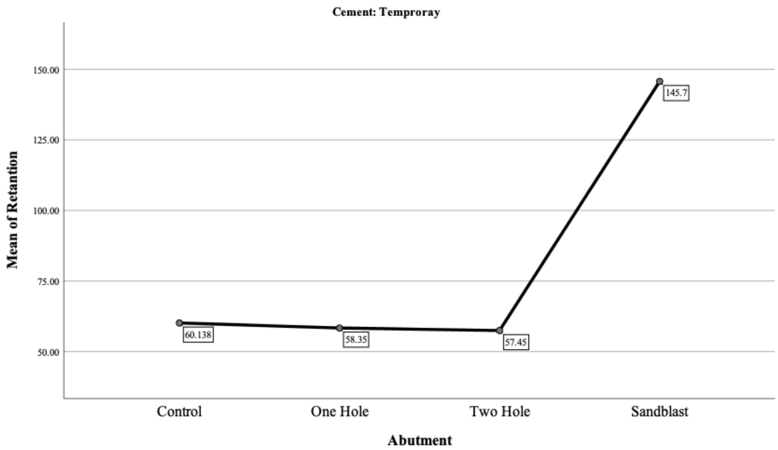

FIGURE 6 Retention levels in implant prostheses cemented with Temp bond in different abutments

TABLE 3 Comparing the retention levels in implant prostheses cemented with Temp bond in different abutments

Group (I)	Group (J)	Mean Difference (I-J)	P value
control	single-vented	1.78	0.993
control	double-vented	2.68	0.978
control	sandblast	-85.56	0.001
single-vented	double-vented	0.90	0.999
single-vented	sandblast	-87.35	0.001
double-vented	sandblast	-88.25	0.001

Table 4 and Figure 7 show the comparison of retention levels in implant prostheses cemented with zinc phosphate in sandblast, single-vented, double-vented, and control abutments. Between the level of retention in sandblast abutments with other groups, there was only a statistically significant difference ($P < 0.05$) (Figure 2). Table 5 reveals the results of the retention level of implant prostheses cemented with zinc phosphate in different abutments.

TABLE 4 Retention level of implant prostheses cemented with zinc phosphate in different abutments

Abutment	Mean ± SD	Lowest	Highest
control	140 ± 11.16	120.4	154
single-vented	170.91 ± 12.02	150	185
double-vented	190.87 ± 13.19	171.2	211.8
sandblast	465.31 ± 19.21	425.7	484
total	241.77 ± 133.10	120.4	484

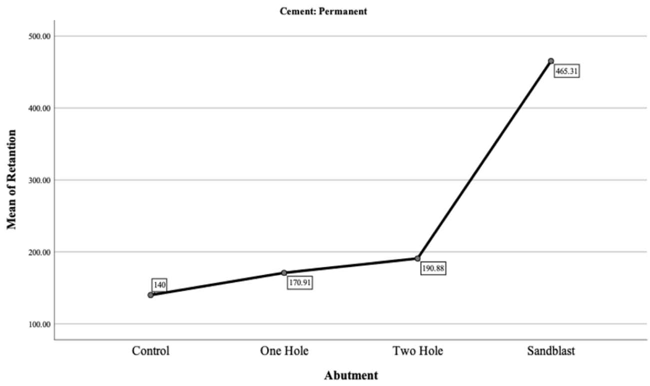

FIGURE 7 Retention level of implant prostheses cemented with zinc phosphate in different abutments

TABLE 5 Results of comparing the retention levels in implant prostheses cemented with zinc phosphate in different abutments

Group (I)	Group (J)	Mean Difference (I-J)	P value
control	single-vented	-30.91	0.212
control	double-vented	-50.87	0.117
control	sandblast	-325.31	0.001
single-vented	double-vented	-19.96	0.043
single-vented	sandblast	-294.40	0.001
double-vented	sandblast	-274.43	0.001

Table 6 shows the comparison of retention rates in implant prostheses cemented with zinc phosphate and temp bond in sandblast, single-vented, double-vented and control abutment. There was a statistically significant difference between all groups ($P < 0.05$).

TABLE 6 Comparison of retention levels in implant prostheses cemented with zinc phosphate and temp bond in different abutments

Cement/abutment	Temporary ±SD	Permanent ±SD	P value
control	60.13± 11.23	140± 11.16	0.001
single-vented	58.35 ± 10.18	170.91 ± 12.02	0.001
double-vented	57.45 ± 12.86	190.87 ± 13.19	0.001
sandblast	145.70 ± 18.12	465.31 ± 19.21	0.001

Discussion

The main benefit of a screwed crown is that it allows for easy exclusion of the crown. Moreover, the probability of the gum inflammation or bone loss decreases in these cases. In two ways, screwed or cemented, the dental prosthesis is attached to the implant by means of abutment [18]. Simplicity of splint, facilitation of prosthetic patio settling, consistency of operation steps with natural dental veneer [24], reduction of fracture fractions, reduction of porcelain fracture, more elegance, improved occlusion setting, less cost and time of treatment are among the advantages of cemented prostheses compared with a variety of screwed methods [18,25]. The greatest drawback of this method of treatment is excessive cement, which may trigger soft tissue inflammation around the implant [4, 18, 26, 27]. In order to monitor the excess cement and improve the adhesion of the crowns of the implant, the configuration of the abutment body is modified through various approaches in many experiments [14, 25]. Vent or groove forming are common forms of improvements in the geometric architecture of the body of the abutments that have been researched so far. The improvements rendered to the structure of the abutment act identically the internal vent which, in addition to the reduction of the cement content, would enhance the settlement of veneer [20, 25]. Currently, implant-based prostheses are a category of cemented restorations that are commonly utilized and have drawbacks such as residual cement and ineffective retention after cementing compared to a range of screwed techniques. The aim of this analysis was to make improvements to the abutment in order to overcome the above issues. The rate of retention in permanent cements according to the results of the present study, is higher than that of temporary cements. The highest retention rate was reported in the group of permanent cements in sandblast implants and then in double-vented and single-vented abutments and finally in the control group, but in the group of temporary cements, the lowest rate of retention was reported in double-vented and single-vented abutments and finally in the control group. Reduced tensile strength of temporary cements opposed to permanent cements, which leads to reduced retention of temporary cements in the event of vent formation, plays an effective role in the occurrence of the above results; the difference was not statistically significant. Cement form plays a key role in the effectiveness of implant prostheses [2]. Permanent cements are frequently not suggested owing to difficult restoration recovery and the possibility of damage to prostheses, abutments and fixtures [15]. According to Wilson's report, in 81% of instances, excessive residual cement around dental implants triggered manifestations of tissue inflammation around the implant. After cement restoration, the period expected for indications of excess residual cement in this sample ranged from 4 months to 9 years, so that the symptoms of inflammation including hemorrhage and soft tissue swelling, arose in the first few weeks, but a few years later, some indications such as peri-implantitis could be detected. In 74% of patients participating in this study, the removal of residual cement completely mitigated symptoms [27]. The findings of various studies suggest that one of the reasons that certain permanent cements are replaced by temporary ones is their suitable retention levels and on the other hand, the residual cement issues are not very serious due to their high extent of solubility [17]. Numerous studies have proposed that the retention of temporary cements can be improved by a number of methods, such as enhancing surface harshness by sandblasting. The results of the present study also confirm the above statements. The retention level observed in the specimens of temporary cements with sandblasted abutment was nearly equivalent to the retention found in the specimens of permanent cements without sandblasting. Sandblasting results in the control of the quantity of impurities, surface roughness, raising the extent of the interface and generating micromechanical retention [10]. The sandblasting technique contains 20 to 250 µm of aluminum oxide particles. Unlike our study, in a 2012 study conducted by Nejatidanesh et al. on standard abutments, there was no disparity between permanent and temporary cements [19]. Using standard abutments and wallless abutments, two temporary cements (Kerr and Dycal) were compared in the study of Farzin et al. Through this research, it was seen that the type of abutment did not play an effective role in cement retention [8]. On the other hand, the use of sandblast on abutment as an important factor in increasing the retention rate of cements is a topic emphasized in various studies including Sahu et al. [22], Ghanbarzadeh et al. (2012) [9], Stern et al. (2011) [16], Hafezghoran et al. (2008) [10], De Campos et al. (2010) [6] and Kim et al. (2006)

[12]. Numerous studies in accordance with our research have also shown that the level of retention may differ based on the type of cement used and the extent of surface harshness [1]. One of the effective factors in increasing the dynamic resistance in different cements is the use of sandblast abutment [28]. The findings of the Campos et al. analysis indicate that the usage of sandblasting abutment may increase the retention rate by 2.4 times in spite of mechanical abutments, which is compatible with our research [6]. As mentioned earlier, the major goal for a screwed crown is to provide simple elimination of the crown if required. Crowns may break in this procedure. Then, it is better to be replaced slightly than restored. The use of a weaker cement is possible; however, it may lead to a risk of the crown loose at some point from the abutment.

Conclusion

Based on the findings obtained in this analysis, it can be inferred that by creating architectural improvements in the body of the abutments, in addition to getting an appropriate amount of retention close to permanent cement clinically, the benefits of temporary cements such as their higher solubility and the avoidance of the possible dangers of the residual cements can be exploited.

Conflict of interest statement

The authors declare that they have no conflicts of interest.

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Orcid:

Shayan Ahmadi: https://orcid.org/0000-0002-0987-6872
Ali Torab: https://orcid.org/0000-0002-0340-871X
Ramin Negahdari: https://orcid.org/0000-0001-5867-5500

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