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A comparative study of retention of cement retained implant prosthesis cemented with different luting cements: An in-vitro study

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***Abstract*---**Purpose: The study was conducted to evaluate the retentiveness of specifically formulated implant cements and compare its retentiveness with a commonly used noneugenol zinc oxide luting cement and also to assess the influence of abutment height on the retentiveness of these cements. Materials and Methods: A master stainless steel mold was used to mount snappy abutment-implant analog complex in acrylic resin. A total of six stock abutments (Osstem TS®) of 4 mm and 5.5 mm height with their analogs were

used. A total of 66 ceramill® Sintron metal copings fabricated using computer-aided design/computer-aided manufacturing system and divided into six groups (n = 11) according to the height (three 4 mm abutment and three 5.5 mm abutment). The cements that were compared were a Noneugenol zinc oxide provisional cement, Dual Cure Resin Cement and a Zinc Phosphate Cement. After cementation samples were immersed in artificial saliva for 7 days and subjected to a pull-out test using a universal testing machine at a crosshead speed of 1 mm/min. The load required to de-cement each coping was recorded and analyzed using one-way ANOVA, post hoc multiple comparison, and independent t-test. Results: Dual Cure Resin Cement had the highest tensile strength followed by noneugenol zinc oxide cement and the least retentive strength was observed in Zinc Phosphate cement. Conclusion: The results suggest that noneugenol temporary resin cement may be considered as a better choice for cementation of implant prosthesis, as it has shown to have better mechanical properties.

***Keywords*---**Acrylic urethane cement, implant luting cements, resin-based temporary cement, tensile strength.

Introduction

Implant supported prosthesis may range from a single tooth replacement to multiple replacements and they are predominantly fixed restorations. The two modes of retention of the suprastructure to the implant abutment component are by means of a prosthetic screw or cement retention. The preferred mode of retention is usually an informed choice made by the clinician based on the need of the clinical situation or the desired outcome. [1]. The screw-retained prosthesis is usually the choices of retention in case of full-arch implant restoration and immediate loading situation as it has the benefits of retrievability excellent marginal integrity and is the only option of retention in situation with decreased interocclusal space. However, they have a few drawbacks, as they need optimum implant positioning and open screw access holes, which may in turn compromise the occlusion and stability of the veneering material. Cemented restorations are a more popular alternative as it exhibits potential advantages over screw-retained restorations. These advantages include elimination of prosthesis screw loosening, enhanced esthetics, establishment of better occlusion, simpler clinical and laboratory steps. However, some disadvantages mentioned in the literature for cement-retained restorations include difficulty in retrieving the abutment and excess cement removal.[1,2,3]

The choice of cement is an important factor for attaining an adequate amount of retention of the implant prosthesis with the feasibility of removal, and thereby improving the longevity of implant prostheses. Temporary luting cements are the most commonly used cement for retention of implant prosthesis and the factors that influence the retention of the cement-retained restorations are well documented, and they are basically the same as those for natural teeth.[4,5,6] Various authors have shown that the choice of cement material, amount of

cement space or internal relief, occlusal forces, and type of luting agent can also affect the retentiveness of final restorations. The ideal cement should be strong enough to retain the crown indefinitely, yet weak enough to allow the clinician to retrieve it if necessary.[7,8,9,10]

One would reasonably expect that those cements generally formulated as permanent luting cements would be at the top of the retention list; however, Mansour *et al.*[11] 2002 found that the rank order of cement retentiveness differed when tested on implants rather than on natural teeth. Abutment surface preparation, and the abutment taper, width, and height also affect the retentive strength of cement-retained implant-supported restorations. At present, the majority of cements used in implant dentistry have been designed for use with the prostheses cemented to natural teeth. Of late, various manufactures have introduced cements specifically formulated for cementation of implant-supported prosthesis, and claim several advantages. However, there are limited studies that have been conducted to study the retentive properties of these specifically designed cements. Therefore, this study was designed to evaluate the cement failure load (CFL) of specifically designed implant cements and to compare it with that of temporary luting cement used commonly for cementation of implant-supported prosthesis.

Materials and Methods

Six implant analogs and 6 implant abutments for Internal Hex Implant of Diameter 4.2 mm (OSSTEM Pvt Ltd, Korea) were used. Nine implant analogs were mounted in individual auto-polymerizing acrylic resin (DPI-RR Cold Cure, Mumbai, India) block (2.9 cm × 1.4 cm) using a dental surveyor. A titanium abutment was placed on each implant analog and torqued at 35 Ncm using a torque wrench. The occlusal access opening and the screw-thread of the abutments were filled with modeling wax before cementation. One implant analog was mounted into a block of auto-polymerizing acrylic resin block of 3 cm × 3 cm. A master coping of auto-polymerizing acrylic resin was formed directly on the implant abutment. According to dimensions of the resin block, a cylindrical custom tray of auto-polymerizing acrylic resin was constructed to make a mold of the master coping with elastomeric impression material (Aquasil, Dentsply, York, Pa).

With the help of this silicone mold, 50 standardized copings were waxed (BEGO, Bremen, Germany) directly onto the unmodified abutment and sprued . The sprue had a minimum of 15 mm length and was parallel to the line of draw of the coping, to be later used as the mechanism of attaching the metal coping to the universal testing machine crosshead (Lloyd LR50K, Ametek, Berwyn, Pa). Finished wax patterns were invested (Bellasun, BEGO) and casted with Ni–Cr alloy (Wiron, BEGO). Fitting surfaces of metal copings were sandblasted with 50μ aluminium oxide particles (Korox 50, BEGO) for 5 seconds. Each metal coping was examined at 3.75 × magnification for surface irregularities on the intaglio surface and seated on the abutment to evaluate marginal fit and complete seating of the coping on abutment under magnification . Then, intaglio surfaces of all the metal copings and the abutments surfaces were steam cleaned.

After all the metal copings were ready, the acrylic block (3 cm × 3 cm) with mounted implant analog–abutment assembly was trimmed to the size as that of other acrylic blocks, that is, 2.9 cm × 1.4 cm. The castings were randomly divided into five experimental groups, with each group consisting of 10 test specimens. The cements used were noneugenol zinc oxide provisional cement , Dual Cure Resin Cement and a Zinc Phosphate Cement. All cements were mixed following the manufacturers' instructions. The test specimens of each group were cemented with one of the five luting cements to be tested. Cements were applied on the axial surface of the copings with a brush to minimize hydrostatic pressure during seating. Copings were seated quickly on the abutment with hand pressure for 10 seconds. This was followed immediately by placement of a 5 kg load with help of cementation jig directed down the long axis of the sprue, maintained for 10 minutes, according to the ADA specification 96 (Figure 3). Specimens were examined visually to confirm complete seating of the coping onto the abutment, referenced by the absence of marginal space. After setting, excess cement was removed using Universal Implant Scaler.

After storing the implant analog–abutment–coping assemblies in physiological saline solution for 24 hours at a temperature of 37°C, the specimens were subjected to tensile loading until separation to determine the retentive strength. Acrylic blocks were gripped with lower tensile jig, and sprues of the copings were attached to the upper tensile jig . Tensile load was applied using 2000 N load cell at a constant crosshead speed of 0.5 mm/min until separation of the copings occurred . The loads at failure were recorded in Newtons. Abutment surfaces were steam cleaned to remove the residual cement. Whenever necessary, remaining cement on abutment surfaces was removed with Universal Implant Scaler. Subsequently, all the test specimens of different groups of luting cements were subjected to testing.

Results

One-way ANOVA was used to compare the mean tensile strength (MPa) between the cement groups at 4 mm abutment height. It was observed that there was a significant difference in the tensile strength between the cement groups; Dual Cure Resin Cement had the highest tensile strength (0.77 ± 0.13) followed by Zinc Oxide Eugenol Cement (0.67 ± 0.25) and the least strength was observed in Zinc Phosphate (0.23 ± 0.12) with $P < 0.001$ [Table 1]. The same observation was noted with 5.5 mm abutment height [Table 2].

Table 1
Mean tensile strength of cement groups in MPa (4 mm abutment height)

	n	Mean±SD	Minimum	Maximum	***P***
ZP	11	0.2327±0.12435	0.10	0.49	<0.001
DCR	11	0.7727±0.13402	0.49	0.98	
ZOE	11	0.6755±0.25025	0.29	1.08	
Total	33	0.5603±0.29491	0.10	1.08	

SD: Standard deviation

Table 2
Mean tensile strength of cement groups in MPa (5.5 mm abutment height)

	n	Mean±SD	Minimum	Maximum	***P***
DCR	11	0.3382±0.24879	0.10	0.88	0.004
ZOE	11	0.7509±0.40399	0.59	1.96	
ZP	11	0.7509±0.23738	0.59	1.18	
Total	33	0.6133±0.35636	0.10	1.96	

SD: Standard deviation

Post hoc Bonferroni test was done for multiple comparisons. It was observed that there is no statistically significant difference between the group ZOE and ZP. However, the groups ZOE and ZP when compared with DCR and showed statistically significant difference in values between each groups ($P < 0.001$) [Table 3].

Table 3
Post hoc Bonferroni test for multiple comparison between each cements

Cement (I)	Cement (J)	Mean difference (I−J)	SE	***P***	95% CI	
					Lower bound	Upper bound
DCR	ZOE	−0.54000*	0.07630	<0.001	−0.7335	−0.3465
	ZP	−0.44273*	0.07630	<0.001	−0.6362	−0.2493
ZOE	DCR	0.54000*	0.07630	<0.001	0.3465	0.7335
	ZP	0.09727	0.07630	0.636	−0.0962	0.2907
ZP	DCR	0.44273*	0.07630	<0.001	0.2493	0.6362
	ZOE	−0.09727	0.07630	0.636	−0.2907	0.0962

Independent *t*-test showed no statistically significant difference between the height groups, although the height-B (5.5 mm) showed better tensile strength when compared to height-A (4 mm). The results showed statistically significant difference between the cements with $P = 0.001$ for 4 mm height and $P = 0.004$ for 5.5 mm height

Table 4
Independent *t*-test for each cement between two heights

	Height		Independent ***t***-test result		
	A	B	***t***-statistic	df	P
Group					
ZP	0.23±0.12	0.34±0.25	-1.258	20	0.223#
DCR	0.77±0.13	0.75±0.40	0.170	20	0.867#
ZOE	0.68±0.25	0.75±0.24	-0.726	20	0.477#

Discussion

In this study metal copings were fabricated and cemented using all the three luting cements, and the tensile load to cause cement failure was recorded using a universal testing machine. The study showed the maximum tensile strength of 1.08 MPa for the DCR The tensile strength recorded for the cement ZOE was almost in the same range and the least tensile strength value recorded was for ZP (0.10 MPa). In this study, Dual Cure resin cement provided secure retention and excellent marginal seal. It is a very tough resin that uses mechanical retention to adhere the crown to the abutment. Yet, when desired, the restoration can be removed easily due to its unique elasticity. Different coefficients of thermal expansion of the materials, a poor marginal seal provided by zinc oxide cements and its high solubility in water could have been the factors responsible for this observation.[12]

Temporary resin cement according to other authors is less retentive compared to other provisional cements. However, it has got certain advantages such as easy retrievability with adequate strength, easy removal of excess cement, and excellent marginal adaptability.[13,14]. Sheets *et al.*, 2008[15] got similar results, they concluded that there was no significant difference between the noneugenol temporary resin cement and noneugenol zinc oxide cement; but the retentive value is better for the noneugenol temporary resin cement. Zinc phosphate cement provides casting retention by micromechanical interlocking into the casting and the abutment surface irregularities. When using smooth titanium implant abutments, the greater compressive strength of zinc phosphate cement compared to polycarboxylate probably does not play a major role in providing retention .[16]

Although there was no statistically significant difference in the values, increasing the abutment height improved the retentive abilitiy of all the cements in the present study. However, in this study, only 4 mm and 5.5 mm heights were investigated. Al Hamad *et al.*, 2011[17] stated that an increasing height was effective with permanent cement but had no effect on temporary cements (e. g., ZOE). Increasing the abutment height by 2 mm was not significant enough to increase the surface area of the abutment and/or the mechanical interlocking of the cement to the point that would result in a statistically significant result. Accordingly Akca *et al.*, 2002[18] observed that abutment height and cement type

affected the Uniaxial Resistance Force (URF) of cements. Similarly, Kent *et al.*, 1997[19] also observed an interactive effect between cement type and abutment height. Covey *et al.*, 2000[20] stated that abutment height and height to width ratio were positively related to retention strength, whereas an abutment total surface area and width were not.

Using these results, the clinician should carefully consider the choice of cement when the risk of component loosening is high; in these situations, the weaker cement may be clinically ineffective. Further research regarding cemented implant crowns may investigate dental cements with various implant systems under validated, standardized *in vitro* conditions. The development of cements specifically for use in implant dentistry may be warranted. Alternatively, dental cements may continue to be selected on a case-by-case basis according to individual cement advantages and the anticipated requirement for crown retrievability. The limitations of the present study were as follows:

- One limitation of this study was the use of pure tensile test. In a clinical situation, it is likely that forces other than tensile can contribute to crown de-cementation. However, the pure tensile testing was used because it has been adopted in other studies and could allow comparison of these results with previous investigations[11,19,22,23]
- The abutments were used 11 times repeatedly for tensile testing; this would change the retentive values of cements. The possibility that changes occur on machined abutment surfaces after cementation and removal of that may alter subsequent retention, has been pointed out in previous studies[18,21,24,25,26]
- The cement space used in this study is 0.05 mm, which may have compromised the retentive properties of the resin-based luting cements, as a higher film thickness would have compromised their physical properties.

Conclusion

Within the limitations of this *in vitro* study, it can be concluded that Dual Cure resin cement may be considered as a better choice for cementation of implant prosthesis, as it has shown to have better mechanical properties such as adequate retentiveness, good marginal adaptation that prevent microleakage, effortless excess cement removal, and also ease of retrievability.

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Conflicts of interest
There are no conflicts of interest.

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