Comparison of Uniaxial Resistance Forces of Cements Used with Implant-Supported Crowns

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Purpose: *Provisional cements are commonly used to facilitate retrievability of cement-retained fixed implant restorations. While the functional life spans of these cements are unpredictable, the relative retentiveness of various permanent and provisional cements between dental alloys and titanium abutments is not well documented. The aim of this study was to compare the uniaxial resistance forces of permanent and provisional luting cements used for implant-supported crowns.* ***Materials and Methods:*** *Seven samples on 4 different abutments (a total of 28 crowns) were cast using a gold-platinum-palladium alloy. The crowns were cemented with 3 different provisional, polycarboxylate, and glass-ionomer cements and 1 zinc phosphate cement. After storage of samples in artificial saliva for 24 hours, tensile tests were performed.* ***Results:*** *While the highest uniaxial resistance forces were recorded for polycarboxylate cements, provisional cements exhibited significantly lower failure strengths (P < .05). The uniaxial resistance force of cements on different abutments exhibited notably different trends; however, more force was required to remove crowns cemented to long abutments (P < .05).* ***Discussion:*** *Glass-ionomer and zinc phosphate cements may be used to increase the maintenance of implant-supported crowns. Temporary cementation of such restorations may necessitate frequent recementation, particularly for restorations on short abutments.* ***Conclusions:*** *Temporary cementation may be more suitable for restorations supported by multiple implants.* (INT J ORAL MAXILLOFAC IMPLANTS 2002;17:536–542)

Key words: *dental cements, implant-supported prosthesis, luting cements, retention*

Fixed implant prostheses used for the treatment of partially edentulous arches are either cement- or screw-retained.[1] The arguments that have arisen between the 2 philosophies have been mainly focused on retrievability, passivity, occlusion, and esthetics. Yet there is no consensus that one method of retention is routinely superior to the other, and the use of either approach depends on the preference of the clinician.

Cement-retained prostheses offer the advantages of axial loading of implants related to the development of optimal occlusal contacts,[1] simplicity in adjustment of the superstructure,[2,3] elimination of screw loosening,[4] and improved esthetics because of the lack of screw access holes.[5] The use of traditional prosthetic techniques, fewer prosthetic components, reduced chair time, cost-effective outcome, and elimination of complications, such as fracture of porcelain, are other advantages reported.[6] Since metal abutments do not have the risk of decay, permanent luting of fixed implant prostheses is not recommended. Because of the high adhesive capacities of permanent cements, provisional luting cements have been mainly preferred to facilitate retrievability of the prosthesis. Nevertheless, the inadequate physical properties of provisional cements, such as low tensile strength and high solubility, have been overlooked in the literature. Factors affecting the tensile strength of cements in implant restorations include abutment height and width, cement type, and cementation technique.[7–12]

Screw retention is often preferred in situations of limited interocclusal space and extended cantilevers.[13] Deep submucosal implant shoulders restrict

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Table 1 Provisional and Permanent Luting Cements Used in the Study

No.	Brand name	Cement	Manufacturer
1	Aqualox	Zinc polycarboxylate	Voco, Cuxhaven, Germany
2	Durelon	Zinc polycarboxylate	ESPE Dental AG, Seefeld, Germany
3	Poly-F	Zinc polycarboxylate	Dentsply Limited, Weybridge, England
4	Meron	Glass ionomer	Voco
5	Vitremer	Glass ionomer	3M Dental Products, St Paul, MN
6	ProTec-Cem	Hybrid ionomer	Vivadent, Schaan, Liechtenstein
7	Sinegol	Non-eugenol	PD Dental, Altenwalde, Germany
8	Procem	Non-eugenol	ESPE Dental AG
9	Temp-Bond	Zinc oxide–eugenol	Kerr, Torino, Italy
10	Poscal	Zinc phosphate	Voco

the use of cemented restorations because of the potential sources of irritation or inflammatory tissue response and scratching of the implant surface during the removal of excess cement.[14,15]

Selection of an implant system is another important factor in determining the feasibility of cement or screw retention of prosthesis.[16] In fact, conical implant-abutment connections such as ITI's Morse taper[17] (Straumann, Waldenburg, Switzerland) provide solutions to screw loosening, which results in higher success rates than those seen with external-hex implants.[18] Currently, retrievability of the prosthesis is nonetheless a nonessential requirement, since survival rates of dental implants have increased substantially.[19] Hence, cement retention could be preferred, especially for single-unit and short-span restorations.

The speculative preference for provisional cements in fixed implant prostheses has been mentioned, as the number of studies reported in the literature concerning the relative retentiveness of various permanent and provisional luting cements between metallic surfaces is insufficient.[13,20] The purpose of this study was to compare the uniaxial resistance force (URF) of various permanent and provisional luting cements used for the cementation of single-tooth restorations on 4 different ITI solid abutments.

MATERIALS AND METHODS

Twenty-one ITI standard solid-screw implants (4.1×10 mm) and 7 wide-neck ITI solid-screw implants (4.8 mm × 6.5 mm [neck] × 10 mm; Straumann) were embedded vertically in autopolymerized polymethylmethacrylate resin (Orthocryl 2000; Dentaurum, Pforzheim, Germany) blocks with a surveyor (Ney Dental International, Bloomfield, CT). The standard-diameter implants were divided randomly into 3 groups of 7 implants each. Seven yellow (4.0 mm height), 7 grey (5.5 mm height), and 7 blue (7.0 mm height) 6-degree solid-screw abutments (Straumann) were connected to these implants with 35-Ncm torque using a torque control device (Straumann) for ratchet. A 6-degree WNI solid abutment (green, 4.0 mm height, Straumann) was connected to each wide-neck implant.

A total of 28 cement-retained restorations (7 in each group) were formed using prefabricated burnout plastic copings. For tensile tests, loops were created over the burnout caps with a spruing wax (Wax wire for sprues [40085]; BEGO Bremer Goldschlägerei, Bremen, Germany). The patterns were invested in phosphate-bonded investment (Dentaurum Castorit Super C). The material was allowed to set for 1 hour and then was placed in a cold oven (Jelenko Accu-Therm II 2000; Sekisui Koji, Osaka, Japan). The burn-out protocol followed the manufacturer's recommendations, and the patterns were cast in a 77.3% gold, 9.8% platinum, and 8.9% palladium alloy (Degudent U; Degussa-Hüls AG, Dusseldorf, Germany) using a casting machine (BEGO Fornax 35EM; BEGO Bremer Goldschlägerei). After deflasking, the restorations were adjusted on the implant abutments using a reamer (8-mm-diameter reamer for 45-degree neck; Straumann), an articulating spray (Occlude; Pascal Company, Bellevue, WA), and tungsten carbide burs. Finally, the inner and outer surfaces of the restorations were sandblasted with 50-µm aluminum oxide particles (S-U-Alustral; Schuler Dental, Ulm, Germany).

The cements used in the study are listed in Table 1. Each cement was mixed according to the manufacturer's recommendations, and a quantity of 0.1 mL, measured by means of an insulin syringe, was applied to the restorations.[7,21] Then, each restoration was seated immediately with finger pressure

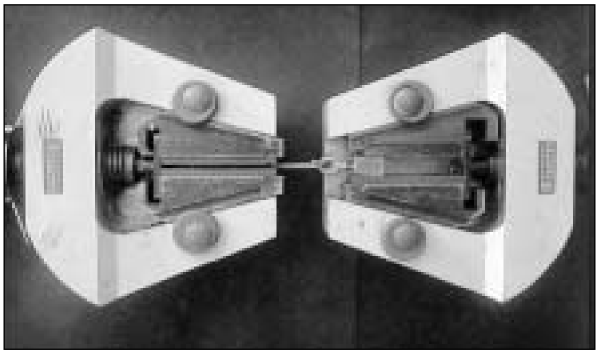

Fig 1 An implant-supported crown secured to the lower clamp of the Lloyd testing machine. A hook was secured to the upper clamp, which exerted a uniaxial tensile force.

and a 50-N static vertical load was applied with a loading device. After setting, the excess cement was removed with an explorer, and the samples were placed in petri dishes filled with artificial saliva and stored in a dark environment at room temperature (24ºC ± 2ºC). The tensile tests were undertaken 24 hours after cementation with an universal testing machine (Lloyd Testing Machine; Lloyd Instruments LR30 K, Segensworth West, Fareham, United Kingdom) with 1,000 N load and a cross-speed of 0.5 mm/s (Fig 1). After the URF of each sample was recorded on different abutments for one cement type, castings and abutments were cleaned in an ultrasonic bath following the procedure[22] that has been described previously as an effective conservation of supplies with no loss of scientific validity.[23] Cements were tested in the following order: #9, #8, #7, #10, #4, #5, #6, #1, #2, #3.

Statistical Analysis

Differences between the URF values of 4 different abutments within and between the cement groups were determined by 1-way analysis of variance (ANOVA) tests, followed by post hoc tests with significance levels set at $P < .05$.

RESULTS

The mean URF values of the cements are shown in Table 2 and illustrated in Fig 2. There were significant differences between the URF values of cements on different abutments within the cement groups ($P < .05$) (Table 3). Post hoc tests within cement groups (Table 4) revealed significant differences between the carboxylate cements for the blue abutment only ($P < .05$). Poly-F exhibited higher URF than Aqualox and Durelon for yellow, grey, and green abutments (469.3 N, 531.1 N, and 475.9 N, respectively) ($P < .05$). Nevertheless, the difference between Aqualox and Durelon was not significant. The URF values between the glass-ionomer cements were notably different for all abutments ($P < .05$). The differences between the provisional cements for yellow and green abutments were significant ($P < .05$). The failure force for Sinegol was lower than that for Procem and Temp-Bond for grey and blue abutments (36.4 N and 43.4 N, respectively) ($P < .05$). However, there was no significant difference between Procem and Temp-Bond.

One-way ANOVA revealed significant differences among the mean URF values of yellow (F: 109.607, $P = .000$), grey (F:223.083, $P = .000$), blue (F:367.245, $P = .000$), and green (F:156.645, $P = .000$) abutments among the cement groups. Post hoc comparison of URF values of all cements on 4 abutments are presented in Table 5. Among all cements, Poly-F exhibited the highest mean URF values on all abutments, followed (in order) by Vitremer, Durelon, and Aqualox ($P < .05$). The lowest URF values in all abutments were observed for Sinegol. Provisional cements had significantly lower URF values than other cements used ($P < .05$).

DISCUSSION

In the present study, it was observed that abutment height and cement type affected the URF of cements. Although the increase was not statistically significant for some groups, the increase in abutment height improved the retentive properties of all cements. Kent and coworkers[7] also observed an interactive effect between cement type and abutment height. They reported an increase in retentive properties of cements on 5.0-mm-high abutments in comparison to 3.7-mm abutments. In the present study, the URFs of cements used on green abutments were slightly higher than values obtained for the yellow abutment. This finding is related to the increased width of green abutments. However, since grey and blue abutments had higher URFs than these abutments, it seems that abutment height has a stronger effect on retentive properties than abutment width. This finding is in agreement with the results of Covey and coworkers,[8] who reported that the retention strength per unit area (MPa) of the wide abutments was lower than that seen for standard size and experimental abutments.

Among the permanent cements, polycarboxylate cements exhibited higher URFs than glass-ionomer and zinc phosphate cements. Polycarboxylate cements do not seem appropriate for cementation of implant-supported crowns. However, glass-ionomer

Table 2 Mean Tensile Bond Strengths (N) and Standard Deviations of Cements on Different Abutments

Cement	Yellow abutment	Grey abutment	Blue abutment	Green abutment
Aqualox	156.1 ± 46.42	221.5 ± 54.79	278.9 ± 45.29	163.6 ± 51.17
Durelon	196.5 ± 75.04	269.2 ± 40.08	325.0 ± 30.52	207.3 ± 47.76
Poly-F	469.3 ± 40.92	531.1 ± 18.40	551.8 ± 11.86	475.9 ± 22.21
Meron	48.2 ± 16.00	81.8 ± 15.07	93.2 ± 9.33	50.7 ± 50.72
Vitremer	236.5 ± 38.00	272.7 ± 27.29	319.8 ± 19.18	240.7 ± 47.33
ProTec-Cem	132.1 ± 21.79	176.5 ± 23.27	243.7 ± 24.62	143.2 ± 18.90
Sinegol	18.9 ± 7.25	36.4 ± 4.40	43.4 ± 3.05	19.8 ± 2.79
Temp-Bond	40.6 ± 4.00	73.1 ± 4.65	81.6 ± 4.65	42.4 ± 4.06
Procem	49.7 ± 9.19	84.2 ± 14.72	94.6 ± 18.91	57.9 ± 20.28
Poscal	61.0 ± 13.24	130.0 ± 7.34	154.8 ± 10.99	65.9 ± 4.72

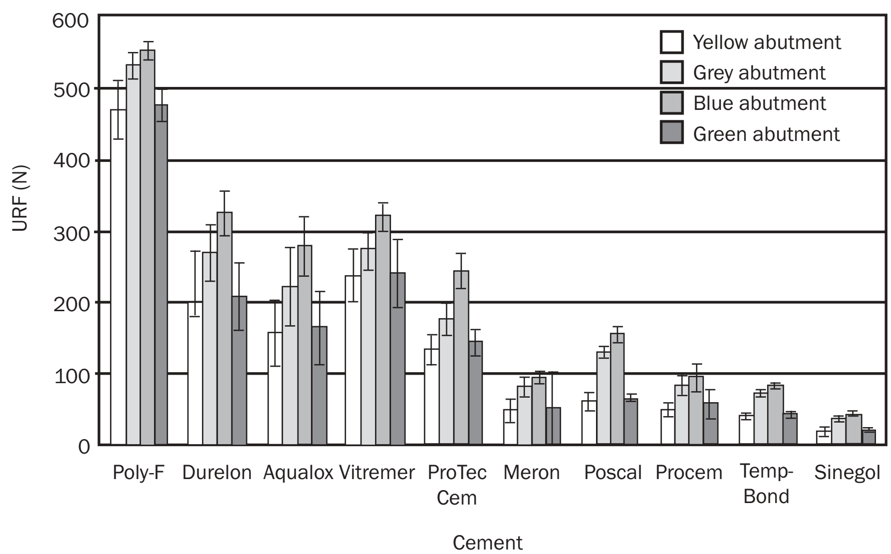

Fig 2 Mean uniaxial resistance forces (URF) of cements for each abutment type.

Table 3 One-Way ANOVA of Abutments Within the Cement Groups

Cement type/ abutment	Sum of squares (MPa)^2	df	Mean square (MPa)^2	F	Significance
Carboxylate cements					
Yellow	406417.8	2	203208.9	64.429	.000
Grey	389068.3	2	194534.2	117.937	.000
Blue	298712.5	2	149356.2	143.400	.000
Green	400516.6	2	200258.3	111.392	.000
Glass-ionomer cements					
Yellow	124513.2	2	62256.604	85.858	.000
Grey	127464.8	2	63732.396	126.270	.000
Blue	186134.2	2	93067.079	263.062	.000
Green	119571.2	2	59785.582	68.172	.000
Provisional cements					
Yellow	3518.567	2	1759.283	34.443	.000
Grey	8764.766	2	4382.383	50.970	.000
Blue	9934.732	2	4967.366	38.832	.000
Green	5146.486	2	2573.243	17.694	.000

Table 4 Post Hoc Test of Abutments Within Cement Groups (n = 7)

Cement type/ abutment	Subset for alpha = .05		
	1	2	3
Carboxylate cements			
Yellow			
Aqualox	156.1		
Durelon	196.5		
Poly-F		469.3	
Grey			
Aqualox	221.4		
Durelon	269.2		
Poly-F		531.1	
Blue			
Aqualox	278.9		
Durelon		325.0	
Poly-F			551.8
Green			
Aqualox	163.6		
Durelon	207.3		
Poly-F		475.9	
Glass-ionomer cements			
Yellow			
Meron	48.2		
Vitremer			236.5
ProTec-Cem		132.1	
Grey			
Meron	81.8		
Vitremer			272.7
ProTec-Cem		176.5	
Blue			
Meron	93.2		
Vitremer			319.8
ProTec-Cem		243.7	
Green			
Meron	50.7		
Vitremer			240.7
ProTec-Cem		143.2	
Provisional cements			
Yellow			
Sinegol	18.9		
Temp-Bond		40.6	
Procem			49.7
Grey			
Sinegol	36.4		
Temp-Bond		73.1	
Procem		84.2	
Blue			
Sinegol	43.4		
Temp-Bond		81.6	
Procem		94.6	
Green			
Sinegol	19.8		
Temp-Bond		42.4	
Procem			57.9

Tukey B; uses harmonic mean sample size = 7.00.
Means for groups in homogeneous subsets are displayed.

Table 5 Post Hoc Test of Abutments Between Cement Groups (n = 7)

Abutment/ cements	1	2	3	4	5	6	7
Yellow							
Sinegol	*						
Temp-Bond	*						
Meron	*						
Procem	*						
Poscal	*						
ProTec-Cem		*					
Aqualox		*	*				
Durelon			*	*			
Vitremer				*			
Poly-F					*		
Grey							
Sinegol	*						
Temp-Bond	*	*					
Meron		*					
Procem		*					
Poscal			*				
ProTec-Cem				*			
Aqualox					*		
Durelon						*	
Vitremer						*	
Poly-F							*
Blue							
Sinegol	*						
Temp-Bond		*					
Meron		*					
Procem		*					
Poscal			*				
ProTec-Cem				*			
Aqualox					*		
Durelon						*	
Vitremer						*	
Poly-F							*
Green							
Sinegol	*						
Temp-Bond	*						
Meron	*						
Procem	*						
Poscal	*						
ProTec-Cem		*					
Aqualox		*					
Durelon			*				
Vitremer			*				
Poly-F				*			

Tukey B; uses harmonic mean sample size = 7.000.
*Means for groups in homogeneous subsets are displayed in rank order.

and zinc phosphate cements may be used to reduce the incidence of cement failure. Significant differences between URFs were also observed within cement groups. This finding may be related to chemical differences that affect the mechanical properties of cements. As observed in the present study, Poly-F demonstrated almost twice the URF of Durelon and Aqualox. Additionally, Sinegol demonstrated the lowest URF among provisional cements. This cement may not be appropriate for the cementation of single-tooth implant restorations.

Although the rationale for temporary cementation was based on the idea of providing ease in retrievability of the prosthesis, quick washout of such cements in the oral cavity possibly poses risks to periodontal health when the maintenance schedule cannot be kept properly. In the present study, the URFs of provisional cements were significantly lower than those of permanent cements. This is attributed to the low chemical and mechanical properties of these cements. The use of such cements together with reduced-height abutments may necessitate frequent recementation of the implant-supported crowns. Accordingly, in a 6-month to 3-year survey of 92 cement-retained fixed partial dentures (FPDs) supported by 225 implants, Singer and Serfaty[24] observed 9.8% cement washout for the restorations, which was attributed to the relatively short abutments supporting FPDs placed in the posterior region and the use of Temp-Bond cement.[12] Since the mean URFs of permanent cements were higher than those of all provisional cements, the use of glass-ionomer or zinc phosphate cements may be recommended for use in posterior cement-retained restorations.

The criteria for using screw or cement retention for fixed implant-supported prostheses in partial edentulism requires further evaluation. Although the gold screws or the occlusal screws used in screw-retained restorations serve as the weakest link in the implant-supported prosthesis, perhaps giving early signs of emerging biomechanical complications, frequent incidences of occlusal screw loosening have been reported.[25,26] On the other hand, although complications associated with cement washout have been reported for cement-retained restorations,[24] such restorations have high clinical success rates.[17,26] Furthermore, since insignificant episodes of abutment loosening (3.6% to 5.3%) have been reported for single-unit ITI solid-screw Morse taper implant restorations,[26] it is unclear whether temporary cementation should be preferred over permanent cementation for these restorations. In light of the present study, it may be recommended that glass-ionomer cements or zinc phosphate cements should be used for cementation of implant-supported crowns on ITI solid abutments. The use of an appropriate cement for a specific restoration type may reduce cement failures. However, the clinical outcome of different cements used for different restorations has not been investigated.

CONCLUSIONS

Within the conditions of this study, the aforementioned conclusions were drawn.

1. The chemical composition of cements used for implant-supported crowns affects the uniaxial resistance force when cemented on implant abutments.
2. Abutment height has a greater impact than abutment width on the uniaxial resistance force of cements.
3. Provisional cements have low uniaxial resistance forces when used with implant-supported crowns. This may necessitate frequent recementation of implant-supported crowns. The use of zinc phosphate or glass-ionomer cements may reduce cement failures.

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