Erosion of Luting Cements Exposed to Acidic Buffer Solutions

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The aim of this study was to evaluate acidic erosion of 7 luting cements. Erosion was evaluated via immersion in 0.1 M aqueous sodium lactate/lactic acid buffer (pH = 2.74 and 4.0, respectively). The rank order of cement loss was as follows: Phosphate Cement > Fuji I hand-mixed = Fuji I encapsulated > Ketac Cem > Calibra = Fuji Plus = Variolink Ultra. Cement type, pH, and time had statistically significant effects. Water-based cements exhibited more erosion compared to resin-based cements, and the latter underwent hygroscopic expansion caused by water sorption. *Int J Prosthodont 2007;20:494–495.*

Erosion in the oral cavity, which contains organic acids and inorganic electrolytes, is a complex phenomenon because the fluid flow has a combined effect of erosion and dissolution.[1] For years, much effort has been devoted to the development of an in vitro test that correlates closely with in vivo disintegration of luting cements.[2,3] Nomoto and McCabe[4] recently introduced a new method and concluded that the results correlated with published data on clinical performance.

The introduction of new adhesive techniques and materials in restorative dentistry has also led to the development of new dental cements that exhibit improved bond strength. Since the number of both clinical and laboratory studies regarding their performance is limited, little information is available pertaining to their erosion behavior.[5] The aim of this study was to evaluate acidic erosion of different luting agents in lactic acid buffer solution of 2 different pH storage mediums.

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Materials and Methods

Erosion of 7 dental cements—1 zinc phosphate cement (Phosphate Cement, Heraus Kulzer), 2 hand-mixed glass ionomers (Ketac Cem, 3M ESPE) (Fuji 1, GC), 1 encapsulated glass ionomer (Fuji 1 Capsule, GC), 1 resin-modified glass ionomer (Fuji Plus, GC), 1 resin cement (Calibra, Dentsply), and 1 highly filled resin cement (Variolink Ultra, Vivadent)—was evaluated using the Nomoto and McCabe[4] method. The cements were mixed according to the manufacturers' instructions.

Specimen holders ($n = 7$ per group) were fabricated in polymethyl methacrylate by drilling an opening measuring 5 mm in diameter and 2 mm deep in the center of each square. After insertion, the square was covered with a polyester strip and a glass slab, allowing excess material to escape. After setting and storage at 90% humidity for 24 hours, the samples were sanded flush with the specimen holder. The heights of 4 predetermined reference points on the specimen holder and 1 point in the center of the material were recorded using a dial gauge (Digimicro MF-501+ MFC-101, Nikon), accurate to 1 µm. The average of the 4 heights of the specimen holder was calculated and the center height was substracted from this value, thus obtaining the baseline depth (D_0). Each measurement was repeated 3 times. The increase in depth or the increase in height caused by expansion was measured after 1 day and 3, 5 , 7, 14, 21, and 28 days of strorage in 0.1 M aqueous sodium lactate/lactic acid buffer at a pH of 2.74 or 4.0. The height measurement at the center of the specimen (D_t) after each specified immersion period was obtained as described above. The height D was calculated using the following equation: $D = D_t - D_o$, where D_o is the baseline measurement of the specimen before immersion and D_t is the height after each specified immersion period.

Table 1 Mean Depth Loss (μm) (SD) Observed for the Tested Cements as a Function of Time and pH (2.74/4.0)*

	Immersion time (d)/pH													
	1		3		5		7		14		21		28	
Cement	2.74	4.0	2.74	4.0	2.74	4.0	2.74	4.0	2.74	4.0	2.74	4.0	2.74	4.0
Zinc Phosphate	188 (8)	48 (3)	421 (10)	134 (8)	582 (21)	199 (13)	702 (21)	257 (15)	1,150 (37)	477 (21)	1,551 (64)	705 (37)	1,877 (111)	924 (46)
Ketac-Cem	5 (2)	0 (2)	38 (4)	3 (2)	74 (6)	3 (1)	104 (12)	5 (2)	293 (26)	8 (2)	487 (29)	14 (4)	666 (45)	15 (3)
Fuji 1 hand-mixed	69 (6)	1 (2)	223 (10)	10 (5)	352 (14)	25 (6)	452 (19)	35 (12)	797 (20)	89 (28)	1,103 (25)	184 (11)	1350 (98)	288 (29)
Fuji 1 encapsulated	61 (6)	2 (2)	205 (15)	8 (6)	327 (25)	20 (6)	423 (28)	28 (9)	759 (24)	81 (32)	1,073 (30)	172 (29)	1350 (30)	273 (22)
Fuji Plus	-7 (3)	-2 (3)	-6 (13)	-3 (4)	-11 (5)	-3 (4)	-10 (8)	-2 (4)	-11 (7)	-4 (4)	-5 (9)	-3 (5)	-8 (8)	-5 (4)
Calibra	0 (2)	0 (2)	-2 (2)	0 (3)	-3 (3)	-1 (2)	-3 (3)	-2 (2)	-4 (4)	-2 (2)	-4 (4)	-3 (2)	-4 (4)	-2 (2)
Variolink Ultra	-1 (2)	0 (0)	-2 (2)	-1 (0)	-3 (2)	-1 (0)	-3 (2)	-2 (1)	-4 (3)	-4 (1)	-5 (3)	-4 (1)	-6 (3)	-5 (1)

*Negative readings indicate expansion.

Repeated measures analysis of variance (ANOVA) and Tukey multiple range tests were performed ($P <$ .001). A regression analysis was performed and the correlation coefficients were calculated to test the linearity of the cement loss of water-based cements against time.

Results

The mean and standard deviations of the depth loss of luting cements are shown in Table 1. ANOVA showed that cement type, pH level, time, and their interactions all had a statistically significant effect on depth loss ($P < .001$). Water-based cements showed higher erosion for both acid conditions, whereas resin-based cements showed hygroscopic expansion rather than depth loss. Tukey multiple range test revealed the greatest depth loss for zinc phosphate cement. Of the 2 glass-ionomer cements, the depth loss of Fuji I was significantly greater than that of Ketac Cem, whereas no significant differences were observed between hand-mixed and encapsulated forms of Fuji I (Table 2).

Table 2 Tukey Multiple Range Test for Differences Caused by Luting Cement*

Group	Mean (μm)	Luting cement
A	-5.47	Fuji Plus
A	-2.89	Variolink Ultra
A	-2.13	Calibra
B	122.53	KetacCem
C	341.54	Fuji I encapsulated
C	355.27	Fuji I hand-mixed
D	658.33	Zinc Phosphate

*Significant differences ($P < .001$) are indicated by different letter groups.

Discussion

The results of this study confirmed that the method described by Nomoto and McCabe,[4] relying on vertical dial gauge measurements, allowed for a comparison of acidic erosion of different luting cements over a period of 7 days while generating reproducible results. This test should be seen as a means to detect the difference between various chemical compositions in an accelerated fashion without adding additonal variables that are present in in vivo experiments.

The higher level of erosion observed for water-based cements should be considered within the context of exposed surface area. The exposed cement surface of 5 mm in diameter, a factor many times larger than a clinically acceptable margin of 40 μm, most likely resulted in an increased loss of material. It also appears that intraoral conditions are considerably less aggressive than this in vitro experimental design, which used a constant low pH lactate acid. To more reliably correlate laboratory data with in vivo conditions, the disolution of 4 cements was followed over a period of 18 months in vivo using intraoral replica techniques and profilometer measurements. The data are currently being analyzed and will be reported later in a separate study.

Conclusions

A linear relationship for erosion and time was observed for the 4 water-based cements. Water-based cements showed greater erosion in both acid storage mediums, whereas resin-based cements did not experience a loss of depth, but rather expanded following hygroscopic expansion caused by water sorption.

References

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