COMPARISON OF RETENTIVE FORCES OF DENTAL CEMENTS ON STAINLESS STEEL CROWNS

by

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Abstract

The purpose of this study was to determine the effect of five dental cements on the retentive properties of stainless steel crowns. Ten primary teeth were prepared and stainless steel crowns were adapted using a standardized procedure. There was a statistical difference between zinc phosphate, carboxylate, and zinc silicophosphate cements when compared to copper phosphate cement and zinc oxide eugenol cement. Copper phosphate cement was the most influential and zinc oxide eugenol cement the least influential on final retention. More force was required to remove the stainless steel crown when the cement remained on the tooth and crown compared to the tooth only. Mechanical retention prior to cementation had little effect on the final retentive value when a precise procedure was followed for adaptation of crown.

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Introduction

The description of usage for stainless steel crowns on primary teeth has been limited to indications, tooth preparations, and adaptation.[1,2] Evidence for an optimum cementing media was not available. This study was undertaken to investigate the effect of five dental cements on the retentive properties of stainless steel crowns.

Review of the Literature

Williams and co-authors[3] measured the amount of tensile force required to remove stainless steel orthodontic bands utilizing five different types of dental cements. They found that significantly more force was required to remove bands cemented with zinc phosphate, or zinc silicophosphate than those seated with zinc oxide eugenol cements. They also noted that zinc phosphate and zinc silicophosphate cements had a somewhat greater tendency to adhere to the polished tooth surface than to the metal bands while the reverse was true with zinc oxide eugenol cement.

In 1968 Smith[4] reported the development of a new dental cement formulation which had adequate strength and was non-irritant, but also possessed the property of adhesion to tooth structure and to some metals. This was zinc carboxylate cement.

Mizrahi and Smith[5,6] investigated the adhesion of stainless steel orthodontic brackets to polished enamel surface under varying conditions. Various types of polyacrylate cements were compared with zinc silicophosphate, zinc phosphate, and copper phosphate cements. The results indicated that the polyacrylate cements had superior adhesion to dental enamel. It was pointed out that for zinc polyacrylate cements the site of failure mainly occured within the cement but the remaining cements failed at the cement/enamel interface.

Mortimer and Tranter[7] evaluated the adhesiveness of carboxylate cement in comparison with zinc phosphate by cementing small stainless steel orthodontic buttons to the enamel surface. They reported that the adhesion tended to be rather erratic since quite a few of the stainless steel buttons fell off before the sample could be mounted in the test machine. Polishing the surface with pumice or even grinding the surface had no significant effect on the quality of the adhesion.

Richter, Mitchem, and Brown[8], evaluating the retentive ability of different types of dental cements, concluded that the carboxylate, zinc phosphate, and hydrophosphate cements were equal while the zinc oxide eugenol cement was approximately one half as retentive. They also demonstrated that the zinc oxide eugenol failed at the cement dentin interface while portions of the other three cements remained attached to the surface of the dentin.

Phillip, Swartz, and Rhodes[9] measured and compared the tensile stress required to separate the carboxylate and zinc phosphate cements from bovine enamel and dentin. It was shown that the carboxylate cement was superior to zinc phosphate with respect to it's ability to adhere to enamel. They reported that failure of carboxylate cement was due to partially or entirely to cohesive failure.

Jendersen and Trowbridge[10] studied biologic and physical properties of carboxylate cement. Comparison was made with zinc oxide eugenol and zinc phosphate cements. The average response for zinc oxide eugenol and carboxylate cements were mild through the test period, but the pulp response to zinc phosphate cement went from moderate to severe.

Methods and Materials

The five cements utilized are listed in Table I. The liquid:powder ratios complied with the consistancy test of A.D.A. specification No. 8. Temrex was mixed using the manufacturer's instructions. Mixing of the cements was done on a glass slab* where optimum temperature could be controlled, while Temrex was mixed on a paper pad.

Prior to crown preparation the extracted primary molars were mounted in a metal ring with cold curing acrylic resin. The crown preparation and adaptation of the stainless steel crown** followed a recommended and standardized procedure.[11] A stainless steel ring was soldered to the occlusal surface of the crown for removal. An intentional effort was made to minimize removal and seating of each crown allowing for optimum adaptation.

A total of ten teeth and five types of cements were used. Each tooth, chosen at random, was thoroughly cleaned and prepared for each new stainless steel crown. A cement, chosen at random, was used for the cementing with an applied force of sixteen pounds. The process was repeated until all five cements were used once and only once on each tooth.

The experimental data consisted of two types, namely, (1) retentive forces and (2) failure patterns. The retentive force of a crown was defined as the force required to pull off a crown (cemented or uncemented as the case may be) from the tooth, mounted in an Instron test device

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* Caulk Temperature Slab, L. D. Caulk Co., Milford, Del. U.S.A.
** Unitek Corp., Monrovia, Calif., U.S.A.

TABLE I

Cement	Manufacturer	liquid:powder cc	Gms	Mixing Time
1. Zinc polycarboxylate (carboxylate) - Durelon	Premier	1.0	1.0	0' 30"
2. Zinc phophate (ZOP) - Fleck's	Mizzy	0.5	1.0	1' 30"
3. Zinc oxide-eugenal (ZOE) - Temrex	Interstate	0.8	1.0	2' 00"
4. Red copper phosphate (CuP) - Fleck's	Mizzy	0.5	1.0	1' 30"
5. Zinc silico phosphate (ZSiP) - Fluoro-Thin	S.S. White	0.4	1.2	1' 00"

with a head removal speed of 0.05 inch per minute according to the test procedure and equipment developed by Richter and co-workers.[8] (Figure 1)

Figure 1
Test apparatus with test specimen mounted

The failure pattern of the cement on each tooth was recorded after the crown was removed. The failure patterns were categorized as follows:

1. Cement adhered mostly to crown (Figure 2).
2. Cement adhered to tooth and crown (Figure 3).
3. Cement adhered mostly to tooth (Figure 4).

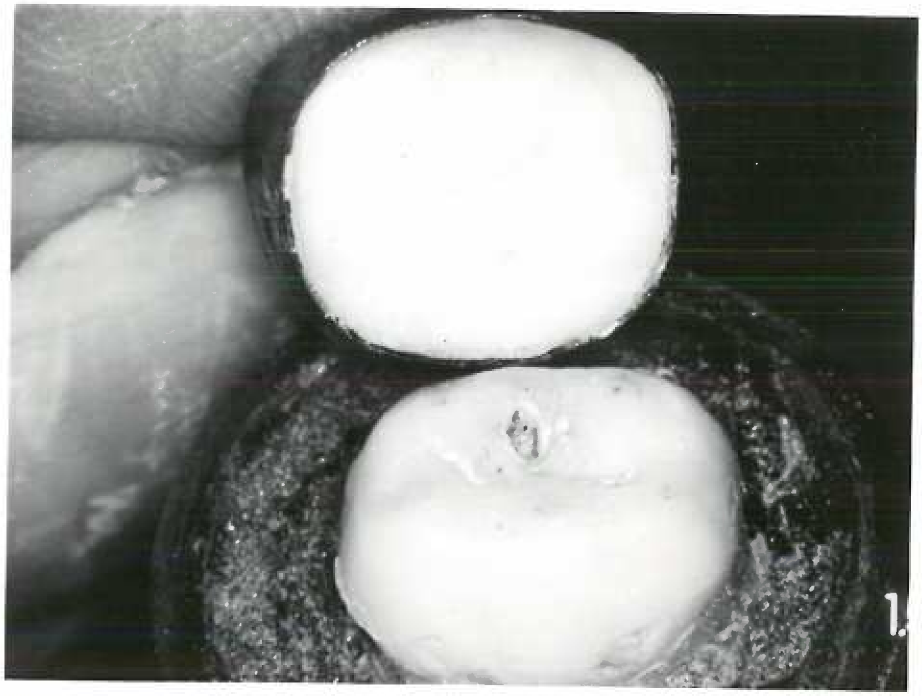


Figure 2 Cement adhered mostly to crown

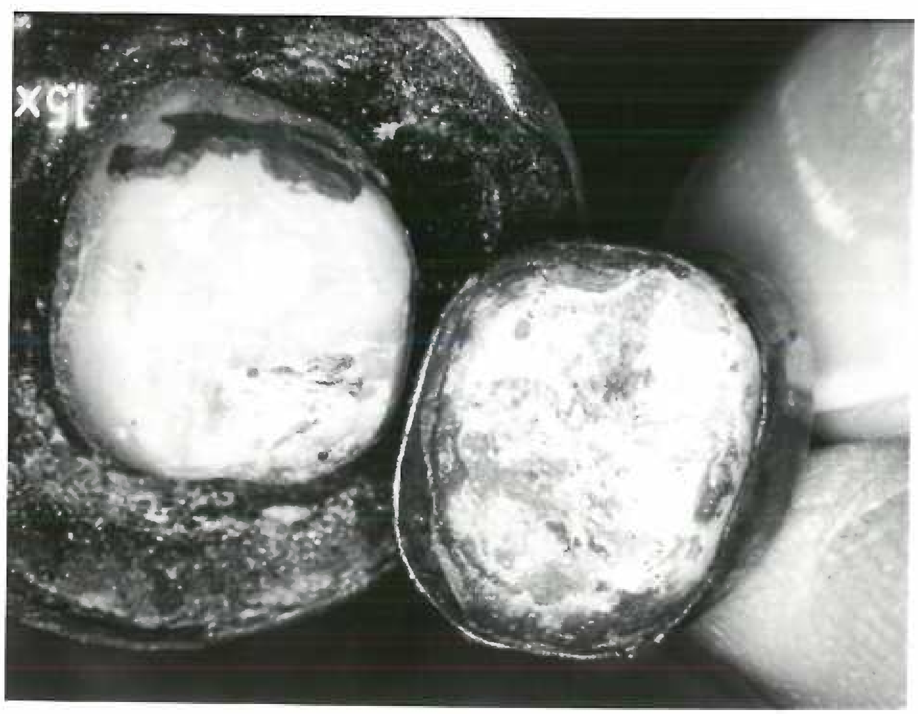


Figure 3 Cement adhered to tooth and crown

Figure 4 Cement adhered mostly to tooth

The following data was analyzed with the primary purpose of detecting significant differences among the five cements.

1. Retentive force with adaptation but without cementation.
2. Retentive force with cementation after the crowned tooth had been stored at 37° C and 100% relative humidity for 48 hours.
3. Failure patterns.

Results and Discussion

A stainless steel crown cannot readily be compared with the mechanical retentive abilities of cast gold crown or a well adapted orthodontic band. As a rule, badly broken down primary tooth structure is usually restored with a stock stainless steel crown in which the thickness of cement may vary from an optimum film thickness to a large mass in the area of carious destruction.

It was found that mechanical retention, removal of the crown prior to cementation, appeared to be unrelated to the final retentive value as evidenced by a correlation coefficient of $r = .08$.

A comparison of failure sites is reported in Table II.

A one-way analysis of variance showed the difference in retention forces with respect to failure patterns were highly significant, i.e. the average retentive forces with respect to patterns 1, 2, and 3 (crown only, crown and tooth, and tooth only) were 35.60 pounds, 47.13 pounds, and 52.45 pounds respectively. (Table III-A)

In view of the possible etching effect of cement No. 4, another analysis of variance was performed excluding the data of cement No. 4. (Table III-B) The results again showed a significant difference, clearly pointing to the fact that the crown-tooth fracture pattern has stronger retentive forces.

The results of analysis of variance with respect to cements and tooth preparations are summerized in Table IV. The mean values (Table V) for the five cements on all ten teeth show that red copper cement

TABLE II

Comparison of Failure Patterns

	Crown only		Crown and Tooth		Tooth only	
	N	$\overline{X}$	N	$\overline{X}$	N	$\overline{X}$
1. Carboxylate	6	36.86	4	52.03		
2. ZOP	3	32.50	7	48.19		
3. ZOE	8	25.76	2	38.75		
4. CuP			8	52.13	2	52.45
5. ZSiP	8	41.30	2	44.10		

N= Number of teeth
$\overline{X}$= Mean force required to remove crowns after cementation

TABLE III A

ANALYSIS OF VARIANCE

Sources	df	S.S.	M.S.	F
Between failure sites	2	5351.77	2675.89	25.80 *
Within failure sites	47	4873.18	103.69	

TABLE III B

EXCLUDING CuP

	df	S.S.	M.S.	F
Patterns	1	3157.29	3157.29	15.15 *
Cement	3	1801.24	600.41	2.88
Error	35	7291.41	208.34	
Total	39	12258.94		

TABLE IV

ANALYSIS OF VARIANCE

Sources	df	S.S.	M.S.	F
Cement (CXT)	4	2991.80	747.95	6.84*
Teeth (T)	9	3299.03	366.56	3.35*
Error (CXT)	36	3934.12	109.28	
Total	49	10224.95		

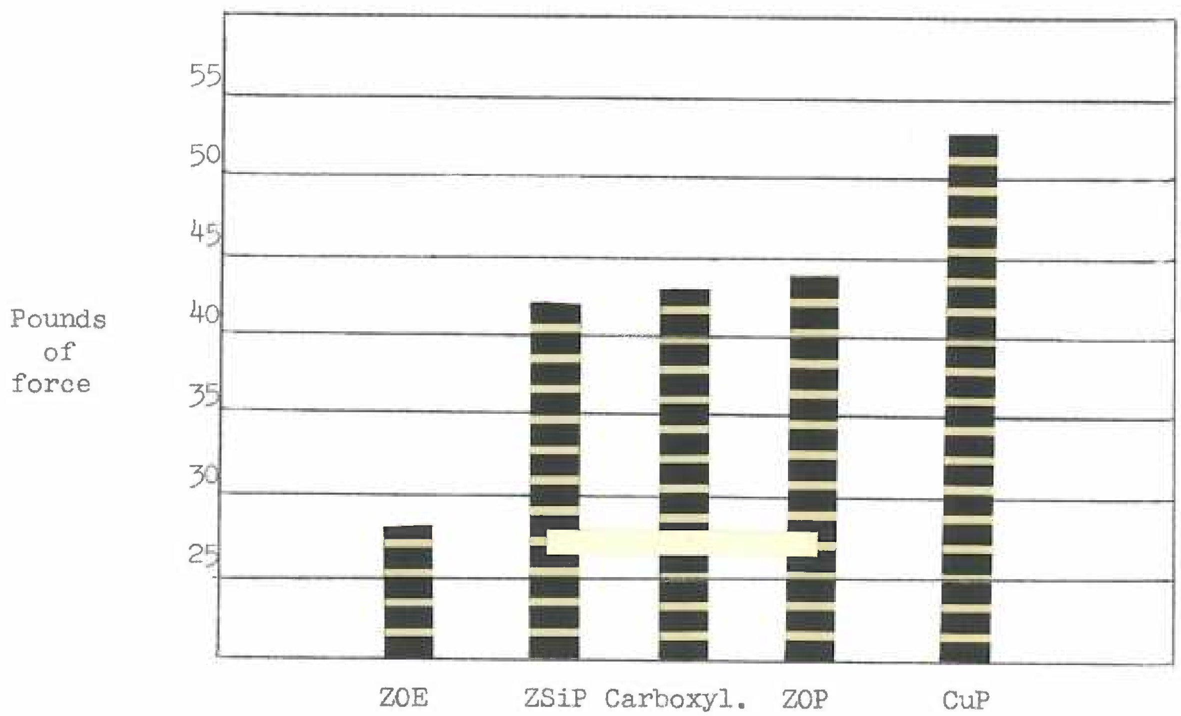
TABLE V

Comparison of the Means
for the Five Cements Used

Cement	Mean
Carboxylate	42.91
ZOP	43.48
ZOE	28.36
CuP	52.50
ZSiP	41.86

had the greatest influence on retention (statistically significant), with zinc phosphate, carboxylate, and zinc silicophosphate a lesser effect. Zinc oxide eugenol had the lowest retention of the stainless steel crowns (statistically significant). (Figure 5)

Figure 5 The retentive values of five dental cements. Horizontal line connects bars that demonstrated no difference in statistical tests.



With the effect of retention obtained from adaptation prior to cementation, showing a low correlation value, the most consistant retentive effect could be attributed to adhesiveness of the cement. The higher retentive potential of copper phosphate cement may be related to it's low initial pH with a resultant acid etching effect on the dentin. Norman and co-workers[12] evaluated the pH of seven dental cements. The pH of copper phosphate cements varied from an initial pH of 2.3 to a pH of 4.7 in 48 hours, whereas the pH of zinc phosphate and zinc silicophosphate went from an initial pH of 5.0 to a pH of 6.8 in 48 hours. As a word of caution, the low pH value of copper phosphate cement might result in probable pulpal damage to vital teeth.

The retention of the crown was significantly different with respect to tooth preparation. (Figure 7) The mean values are reported in Table VI. Sample tooth No. 5 had higher values for all cements used whereas the preparation of tooth No. 8 contributed the least to the retention of the stainless steel crowns. Thus the structure must be prepared precisely to allow for maximum mechanical luting of the cementing media, stainless steel crown, and remaining structure.

Figure 7 The mean retentive values of the ten teeth. The horizontal line connects bars that demonstrated no difference in statistical tests.

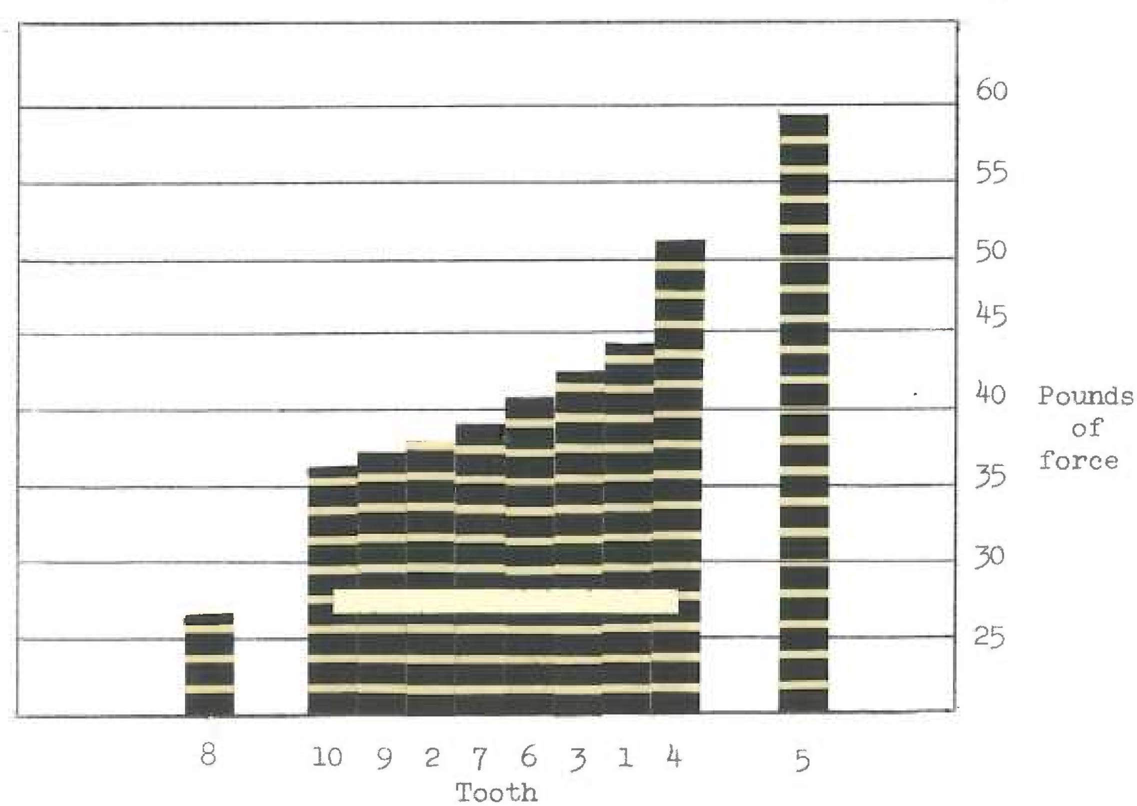


TABLE VI

Comparison of the Effect of the Individual Teeth on Retention

Tooth	Mean
T1	44.50
T2	38.62
T3	42.54
T4	51.22
T5	59.11
T6	40.88
T7	39.32
T8	27.46
T9	37.80
T10	36.78

Summary and Conclusions

In a laboratory experiment five dental cements were used to cement stainless steel crowns to primary teeth with the following results:

1. Mechanical retention prior to cementation was not a factor in contributing to overall retentive values.
2. The crown-tooth fracture pattern has stronger retentive values than the crown only pattern.
3. The average retentive forces of the five cements are 52.50 (CuP), 43.48 (ZOP), 42.91 (Carboxylate), 41.86 (ZSiP), and 28.36 (ZOE). No significant differences were observed in the middle group of ZOP, carboxylate, and ZSiP. However, CuP was significantly higher and ZOE was significantly lower than this group. The differences of the tooth preparation caused variation in crown retention.

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