

## A clinical evaluation of polished and unpolished amalgams: 18-month results

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### Abstract

*Twenty-six patients, 5-13 years of age, demonstrated 67 pairs of contralateral occlusal fissure and buccal, or lingual pit carious lesions which were restored with a spherical high-copper amalgam. One restoration of each pair was allowed to remain as carved, while the other was finished and polished 24 hours after insertion. Each restoration was evaluated clinically by three independent examiners. Black and white photographs were taken at baseline, 6, 12, and 18 months for a comparative indirect evaluation. Clinically, margin adaptation became more detectable from baseline to 18 months for both restorations with no significant difference between the two methods of finishing. Photographically, marginal adaptation also deteriorated from baseline to 18 months, with significant difference from the previous evaluation at both 6 and 18 months, but no difference between the two methods. The surface texture was significantly different between the two methods at all recall evaluations.*

**T**he development of high-copper dental amalgam has resulted in alloys with improved physical properties and handling characteristics as compared to conventional dental amalgams.<sup>1</sup> These include improved marginal adaptation, increased resistance to surface corrosion, and lower static creep.

It has been reported that marginal adaptation and resistance to surface corrosion have been enhanced by postinsertion finishing and polishing techniques.<sup>2,4</sup> The effects of finishing and polishing on marginal adaptation are disparate, commonly derived from laboratory studies which have reported that finished amalgam restorations demonstrated more regular margins compared to carved-only restorations. However, following finishing and polishing, frequent marginal gaps have been reported between the amalgam and the enamel surface.<sup>5,8</sup>

The aim of this study was to compare high-copper amalgam restorations which were allowed to remain as carved with similar restorations that were finished and polished after a postinsertion period of at least 24 hours. Written criteria for marginal adaptation, anatomic form, surface texture, occlusal morphology, and caries were used to evaluate each restoration clinically. Marginal adaptation also was evaluated indirectly utilizing clinical photographs. Eighteen-month results are reported as part of a three-year clinical project.

### Methods and Materials

Twenty-six patients (age 5-13 years) selected for this study demonstrated 50 contralateral pairs of permanent and primary molars with incipient occlusal caries, and 17 pairs with carious buccal or lingual pits. Following administration of local anesthesia and isolation of the appropriate teeth with a rubber dam, Class I cavities were prepared with a #56 fissure bur in a high-speed handpiece. Any deep caries was removed with an appropriate size round bur in a conventional-speed contra-angle handpiece. Pulp protection in deep cavity preparations was achieved using Dycal<sup>a</sup> as a liner, cavity varnish<sup>b</sup> to seal the dentin walls, and zinc phosphate cement base<sup>c</sup> to provide ideal cavity depth. The preparations were refined with a #56 bur at conventional speed.

After debridement, a single coat of cavity varnish<sup>b</sup> was placed over all internal cavity walls and margins. Regular set Tytin amalgam in 800 mg capsules<sup>d</sup> was triturated with an S.S. White Capmaster<sup>e</sup> amalgamator for 6 seconds and carried to the preparation, condensed and over-packed with a 1.4 x 2.0 mm elliptical condenser using hand pressure. The amalgam first was burnished

<sup>a</sup> Dycal, L.D. Caulk Co.: Milford, Del.

<sup>b</sup> Copalite, Cooley & Cooley, Ltd.: Houston, Texas.

<sup>c</sup> Missy, Inc.: Clifton Forge, Va.

<sup>d</sup> S.S. White Dental Products International: Holmdel, N.J.

<sup>e</sup> S.S. White Division of Pennwalt Corp.: King of Prussia, Pa.

with a #21B anatomical burnisher<sup>f</sup> and carved with a 7C discoid/cleoid carver<sup>f</sup> followed by a 5C carver.<sup>f</sup> An S.S. White #3 explorer<sup>g</sup> was used to refine and remove flash at the margins. All amalgams were packed and carved within 8 minutes of the start of trituration.

From each pair, one restoration was selected randomly to be finished and polished after 24 hours while the other remained as carved. Initial finishing was done with a #6 or a #4 pear-shaped bur at conventional speed, and the grooves were refined with a #2 round finishing bur or a #0 flame-shaped bur. Each restoration selected was polished with a thin slurry of XXX Silex<sup>h</sup> at conventional speed and then a creamy mix of tin oxide.

The amalgams were evaluated using modified criteria from Ryge<sup>9,12</sup> for: marginal adaptation, anatomical form, surface texture, occlusal morphology, and caries<sup>12</sup> at baseline and at each subsequent six-month recall appointment.

Black and white photographs also were taken of each tooth at baseline and at six-month intervals using a camera with a 200 mm macrolens set at 1.5x. The black and white photographs then were enlarged to 6.4x for evaluation of marginal adaptation and flash. A modification of Mahler's method of photographic evaluation for marginal adaptation<sup>13</sup> was developed using six photographs of representative restorations, depicting each of the modified criteria used for the clinical evaluation.<sup>12</sup> The amount of marginal overextension (flash) also was accessed photographically for each restoration.<sup>12</sup>

A consensus was reached when at least two of the three examiners agreed independently on the same rating for each clinical and photographic evaluation. If no consensus occurred, the three examiners reviewed the clinical

<sup>f</sup>E.F. Wessler Manufacturing Co.: Cleveland, Ohio.

<sup>g</sup>S.S. White Division of Pennwalt Corp.: Philadelphia, Pa.

<sup>h</sup>Moyco Industries, Inc.: Philadelphia, Pa.

<sup>i</sup>Matheson, Coleman & Bell: Norwood, Ohio

or photographic scoring in order to reach a consensus agreement. The values obtained from the ratings of the three examiners using the modified Ryge explorer examination were converted to corresponding ratings of the Dental Health Center rating scale. Interexaminer agreement was calculated for both methods to allow comparison.

## Results

At baseline, 67 pairs of amalgam restorations were evaluated. At the subsequent 6-month recall appointments, the number diminished to 57 pairs (85%) and to 48 pairs (72%) at 12 and 18 months.

Two clinical criteria (anatomic form and caries) demonstrated no significant changes either within or between the two groups at any evaluations during the 18 months of the study (Table 1).

The clinical criteria for occlusal morphology demonstrated a significant difference between carved-only and 24-hour polish at 6-12 months, but not at 18 months (Table 1).

The clinical evaluation of marginal adaptation revealed no significant difference between the carved-only and the 24-hour polished restorations at baseline, 6 or 18 months, but at 12 months the polished restoration exhibited significantly better marginal adaptation. The ratings for all marginal adaptation progressively deteriorated from baseline through 18 months within each method (Tables 1-3). In the restorations that remained as carved, the only significant differences occurred from baseline to 6 months and baseline to 18 months. Within the group polished at 24 hours, there were significant differences from baseline to 6 and 18 months. At 12 months the mean value for adaptation was similar to the mean at baseline (Table 1).

The photographic evaluation of marginal adaptation

Table 1. Mean Values Comparing Carved-Only to Polished Restorations

	Baseline		Clinical Evaluation					
	Carved X ± S.D.	Polished X ± S.D.	6 Months		12 Months		18 Months	
			Carved X ± S.D.	Polished X ± S.D.	Carved X ± S.D.	Polished X ± S.D.	Carved X ± S.D.	Polished X ± S.D.
N. =	67 pairs		57 pairs		48 pairs		48 pairs	
M.A. =	1.93 ± .26	1.89 ± .31	2.09* ± .39	2.07* ± .42	2.00 ± .36	1.87* ± .44	2.125 ± .64	2.12* ± .56
A.F. =	1.07 ± .26	1.03 ± .17	1.07 ± .26	1.02 ± .13	1.02 ± .14	1.02 ± .14	1.02 ± .14	1.02 ± .14
S.T. =	3.18 ± 1.03	1.01 ± .12	3.10* ± .79	2.00* ± .00	2.98 ± .96	2.02 ± .14	2.96 ± .68	2.12 ± .39
O.M. =	1.07 ± .26	1.01 ± .12	1.16 ± .37	1.02 ± .13	1.21 ± .41	1.06 ± .24	1.00 ± 0	1.00 ± 0
Ca. =	1.00 ± .00	1.00 ± .00	1.00 ± .00	1.00 ± .00	1.00 ± .00	1.00 ± .00	1.00 ± 0	1.00 ± 0
	Photographic Evaluation							
M.A. =	1.54 ± .50	1.76 ± .46	2.07* ± .53	2.02* ± .58	2.12 ± .44	2.04 ± .41	2.40* ± .58	2.33* ± .63
F. =	1.91 ± .67	1.78 ± .60	1.93 ± .59	1.82 ± .60	1.81 ± .61	1.58* ± .68	1.67 ± .48	1.56 ± .62

KEY: N. = Number of Pairs M.A. = Marginal Adaptation A.F. = Anatomic Form S.T. = Surface Texture O.M. = Occlusal Morphology Ca. = Caries F. = Flash Rating

° = Significant between the two polishing methods at the same time period (p < .05).

\* = Significant between the previous time period for the same polishing method (p < .05).

x = Significant between clinical versus photographic evaluated ratings for margins at the same time period (p < .05).

produced a significantly lower mean value at baseline for carved-only than for those polished after 24 hours. The ratings for marginal adaptation worsened progressively from baseline through 18 months (Figures 1 & 2) for both methods, with significant differences from the previous 6-month period at both 6 and 18 months (Tables 1 & 2b).

Clinically, there were significant difference in surface texture between the carved-only and polished restorations beginning at baseline and continuing through 18 months (Tables 1, 4, & 5; Figure 3). At baseline the carved-only restorations appeared granular in texture while those restorations polished at 24 hours had a shiny, reflective surface (Figures 1-3). By 18 months, the carved-only restorations were granular, with some areas of smoothness in texture while the polished restorations were satiny smooth in texture (Figures 1 & 2).

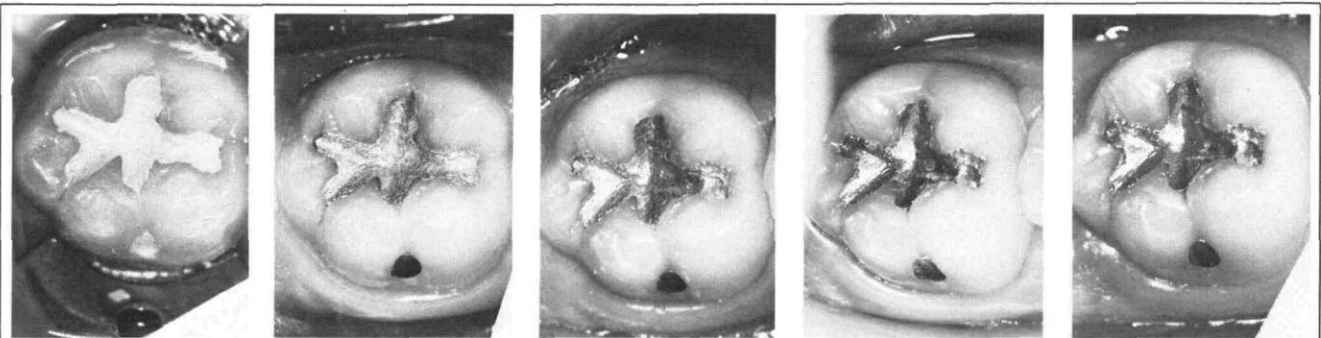
Photographic analysis revealed a lower rating for flash at baseline in the polished restorations than in the carved-only (Figures 1 & 2). At 6 months, both groups of restorations remained about the same, but at 12 months there was a significant difference between the groups, with the 24-hour polished restorations having less flash present. Also, at 12 months, the polished restorations had significantly less flash than the previous 6-month period. This could be an error in the rating method because by

18 months both groups again exhibited similar amounts of flash (Tables 1 & 6).

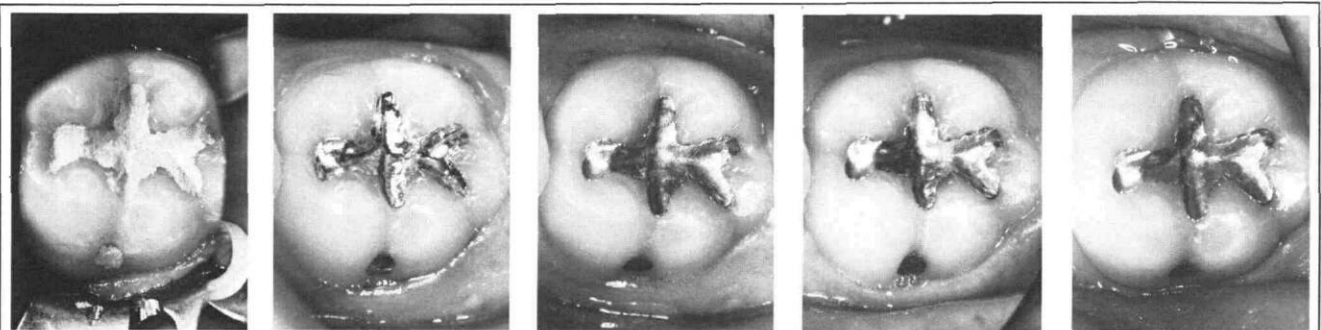
Using the Dental Health Center scale<sup>9,12</sup> the consensus agreement for the clinical evaluations of anatomic form, occlusal morphology, surface texture, marginal adaptation, and caries was 100% for the 18 months of this study. The consensus agreement for the photographic evaluations of marginal adaptation and flash was a range of 99.5% and 98.7%, respectively, for 18 months. Using the modified Ryge evaluation,<sup>11,12</sup> the average of the three evaluators' clinical evaluations, using a two-way analysis were: anatomic form — 93.0%; occlusal morphology — 92.0%; surface texture — 92.2%; marginal adaptation — 80.0%; and caries — 100% for the 18 months. The percentages for the photographic evaluations were: marginal adaptation — 68.9%; and flash — 60.0% for the 18 months.

## Discussion

High-copper amalgam alloys consistently have demonstrated clinical superiority over conventional amalgam alloys.<sup>13-16</sup> The spherical high-copper amalgam (Tytin), a unicomposition alloy, was selected for use in this study because of its early compressive and tensile strengths<sup>6</sup> and low creep.<sup>17,18</sup> Corpron and coworkers<sup>19</sup>

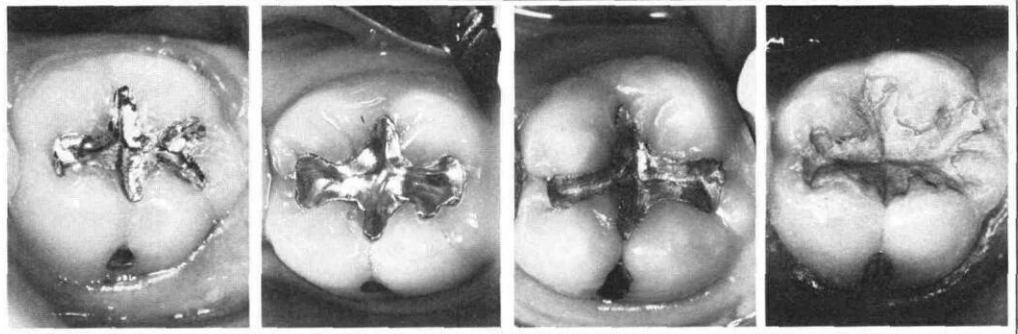


**Figure 1.** A carved-only restoration (6.4x) the pair to Figure 2. (Consensus ratings from Table 1.) a — Immediate postoperative; b — Baseline MA-2, ST-3, M-2, F-3; c — Six months MA-2, ST-3, M-2, F-2; d — Twelve months MA-2, ST-3, M-2, F-2; e — Eighteen months MA-2, ST-3, M-3, F-2.



**Figure 2.** A 24-hour polished restoration (6.4x) the pair to Figure 1. (Consensus ratings from Table 1.) a — Immediate postoperative; b — Baseline MA-2, ST-1, M-2, F-2; c — Six months MA-2, ST-2, M-2, F-2; d — Twelve months MA-2, ST-2, M-2, F-2; e — Eighteen months MA-2, ST-2, M-3, F-1.

**Figure 3.** Surface texture ratings: a — Glossy; b — Satiny; c — Granular; d — Dull.



conducted a clinical study comparing an early polish (8 minutes) of occlusal amalgam restorations to the conventionally polished restorations using Tytin amalgam. Clinically and photographically, marginal adaptation deteriorated from baseline to 36 months with both methods in a manner similar to restorations in this study.

Interestingly, the photographic analysis of this study at baseline showed that the margins of all restorations were significantly better than was found in the clinical analysis (Tables 1-3 & 7); but by 18 months, the photographic analysis showed the margins to be significantly more deteriorated than in the clinical analysis (Tables 1 & 7). Thus, each marginal analysis, either clinical or photographic, started with a different value at baseline, and by 18 months the photographic marginal

adaptation showed the greatest change over time, although this progression was not consistent and did not correlate well with the clinical results.

It has been speculated that practitioners do not polish amalgam restorations routinely.<sup>20</sup> This may be due to the widely held concept that polishing procedures should be delayed at least 24 hours.<sup>24,21</sup> Birtcil and coworkers<sup>22</sup> concluded that marginal performance was less affected by finishing procedures in high-copper amalgams and stated that the high-copper alloys may not have to be finished at all to perform well clinically. They also found that the smaller restoration generally exhibited better marginal adaptation and much less clinical deterioration with time. This study demonstrates no differences in marginal adaptation and, therefore, polishing may not

**Table 2a.** Clinical Consensus for Marginal Adaptation

Margin Ratings	Baseline		6 Months		12 Months		18 Months	
	N		N		N		N	N
	67	24-hour	57	24-hour	48	24-hour	48	49
	Carved-Only	Polish	Carved-Only*	Polish*	Carved-Only	Polish*	Carved-Only	24-hour Polish*
1—No detection	5	7		1	3	8	4	2
2—Less than 50%	62	60	54	53	42	38	37	42
3—Greater than 50%			1	1	3	2	4	2
4—Crevice less than 50%			2	2			3	3
5—Crevice greater than 50%								
6—Crevice to the dentin								

\*Significant difference within method from previous time period- (Pairwise t-test,  $p < .50$ ).

**Table 2b.** Photographic Consensus for Marginal Adaptation

Margin Ratings	Baseline		6 Months		12 Months		18 Months	
	N		N		N		N	N
	67°	24-hour	57	24-hour	48	24-hour	45	46
	Carved-Only	Polish	Carved-Only*	Polish*	Carved-Only	Polish	Carved-Only*	24-hour Polish*
1—No detection	31	17	5	8	2	3	1	3
2—Less than 50%	36	49	44	41	38	40	26	25
3—Greater than 50%		1	7	7	8	5	17	17
4—Crevice less than 50%			1	1			1	1
5—Crevice greater than 50%								
6—Crevice to the dentin								

\*Significant difference within method from previous time period- (Pairwise t-test,  $p < .05$ ). O-Significant difference between methods within one time period- (Pairwise t-test,  $p < .05$ ).

**Table 3. Comparison of Margins — Carved-Only Versus Polished in Clinical and Photographic**

Evaluation	N 67 Baseline			N 57 6 Months			N 48 12 Months			N 48 18 Months		
	Carved Less Dect.	Carved More Dect.	No Diff.	Carved Less Dect.	Carved More Dect.	No Diff.	Carved Less Dect.	Carved More Dect.	No Diff.	Carved Less Dect.	Carved More Dect.	No Diff.
Clinical	2	4	61	* 2	3	52	1	7	40	* 8	6	34
Photographic	°20	5	42	* 8	10	39	2	6	40	8	12	25

\*Significant difference within method from previous time period (Pairwise t-test,  $p < .05$ ) O-Significant difference between methods (Wilcoxon matched-pair rank-sum test,  $p < .05$ ).

**Table 4. Consensus for Surface Texture Clinical Evaluation**

Ratings	N 67° Baseline		N 57° 6 Months		N 48° 12 Months		N 48° 18 Months	
	Carved- Only	24-hour Polish	Carved- Only	24-hour Polish	Carved- Only	24-hour Polish	Carved- Only	N 49 24-hour Polish
1—Shiny		66						
2—Smooth-satiny		1		57	7	47	6	45
3—Granular		65		56	40	1	41	3
4—Dull		2		1	1		1	1

O-Significant difference between methods at one time period (Pairwise t-test  $p < 0.5$ ) \*Significant difference within method from previous time period- (Pairwise t-test,  $p < .05$ ).

**Table 5. Comparison of Surface Texture — Carved-Only Versus Polished**

Evaluation	N 67 Baseline			N 57 6 Months			N 48 12 Months			N 48 18 Months		
	Carved Smoother	Polished Smoother	No Diff.	Carved Smoother	Polished Smoother	No Diff.	Carved Smoother	Polished Smoother	No Diff.	Carved Smoother	Polished Smoother	No Diff.
Clinical	°0	67	0	°0	57	0	°1	41	6	°4	40	4

O-Significant difference between methods at one time period (Wilcoxon matched-pair rank-sum test,  $p < .05$ ).

**Table 6. Comparison of Margin Overextension (Flash) — Carved-Only Versus Polished**

Evaluation	N 67 Baseline			N 57 6 Months			N 48 12 Months			N 45 18 Months		
	Carved has Flash	Carved has Flash	No Diff.	Carved has Flash	Carved has Flash	No Diff.	Carved has Flash	Carved has Flash	No Diff.	Carved has Flash	Carved has Flash	No Diff.
Photographic	10	19	38	8	14	35	°4	13	31	9	13	23

O-Significant difference between methods at one time period Wilcoxon matched-pair rank-sum test  $p < .05$ ).

**Table 7. Comparison of Margins — Clinical Versus Photographic in Carved-Only and 24-hour Polish**

Evaluation	N 67 Baseline			N 57 6 Months			N 48 12 Months			N 45 18 Months		
	Clinical Margins Less Dect.	Clinical Margins More Dect.	No Diff.	Clinical Margins Less Dect.	Clinical Margins More Dect.	No Diff.	Clinical Margins Less Dect.	Clinical Margins More Dect.	No Diff.	Clinical Margins Less Dect.	Clinical Margins More Dect.	No Diff.
Carved-Only	°0	26	41	6	7	44	8	2	38	°16	2	27
24-hour Polish	6	15	46	7	10	40	12	4	32	14	4	28

O-Significant difference between evaluation methods within one time period (Wilcoxon matched-pair rank-sum test,  $p < .05$ ).

produce better margins. Surface texture was significantly rougher for the unpolished restorations and only time will provide the clinical significance of these results.

Rupp<sup>23</sup> listed six reasons for marginal deterioration: (1) retention of excess mercury, (2) improper cavity preparation, (3) failure to carve or finish the amalgam flush to the margins of the preparation, (4) moisture contamination, (5) corrosion, and (6) creep. In this study, a high-copper alloy (Tytin) was used with rubber dam isolation. Emphasis was placed on proper outline form for the Class I restorations as well as the necessity for proper carving or finishing of the amalgam flush to the margins of the cavity preparations to avoid overextension of the amalgam at the margins (Figures 1 & 2).

The effects of time on the surface of the amalgam restorations were evaluated (Tables 1, 4 & 5; Figure 3), and early observation of the carved-only restorations revealed a granular texture of the surface, which by 18 months still demonstrated a granular appearance (Tables 4 & 5; Figures 1 & 2). Six of the carved-only restorations moved into the "satin finish" rating by 18 months (Table 4). This self-polishing of the occlusal amalgams may result from repeated mastication.

The advantages of polishing amalgam restorations have been suggested by several investigators,<sup>2,4,24</sup> generally without the benefit of qualitative longitudinal clinical comparison. In order to compare the effects of carved-only to conventional polishing methods, the most precise methods available were modified and utilized for this present investigation. After 18 months the amalgam restorations allowed to remain as carved did not appear to accumulate more plaque nor was there any evidence of recurrent decay around the restoration margins.

## Conclusions

When an ideal cavity outline form, good rubber dam isolation, proper condensation, and carving to the margins were achieved, the following conclusions could be stated:

1. There was no difference in marginal integrity between carved-only and conventionally polished restorations (Tytin) through 18 months.
2. The ratings for marginal integrity progressively deteriorated from baseline through 18 months for both procedures.
3. The photographic marginal analysis at 18 months demonstrated a significantly more detectable margin than was found in the clinical evaluation.
4. Surface texture was significantly smoother for the conventionally polished restorations at baseline and continued throughout the 18 months.
5. There were no changes in anatomical form and no evidence of secondary caries.

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