

## A clinical evaluation of polishing amalgams immediately after insertion: 18 month results

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### Abstract

*Thirty-three patients, 7-13 years of age, demonstrated 96 pairs of contralateral occlusal fissure and buccal and lingual pit cavities which were restored with a high-copper amalgam. One restoration of each pair was polished with a slurry of XXX Silex in an unwebbed rubber cup at eight minutes following trituration. The contralateral restoration was finished at least 24 hours after insertion with pear-shaped finishing burs and polished with a slurry of XXX Silex, followed by a slurry of tin oxide. Each restoration was examined clinically for five criteria by three examiners and black and white photographs were taken at baseline and at each six-month recall appointment for 18 months.*

*Clinically, marginal adaptation worsened from baseline to 18 months with both methods of polishing, but there was no significant differences between the two methods. However, a significant difference in marginal adaptation was evident by photographic evaluation. The surface texture of eight-minute polished restorations at baseline was granular compared to the glossy surface of restorations polished at 24 hours, but by 18 months, the surface texture of the restorations polished by the two methods was very similar.*

**P**erhaps the greatest challenge to the longevity of amalgam restorations is observed in children in the primary, mixed, and young permanent dentitions. During such periods, when dynamic changes in the developing occlusion and peaks in caries activity are characteristic, the majority of decayed primary and young permanent teeth are restored with amalgam. Failures of such amalgam restorations are generally due to faulty cavity design, improper manipulation of the amalgam, or inadequate physical properties of the amalgam which lend to poor marginal adaptation and significant potential for recurrent decay.

Benefits reported for the well-finished and polished amalgam restoration include improved

marginal adaptation, reduced surface tarnish and marginal corrosion, and smoother surfaces and margins which are less susceptible to plaque accumulations.<sup>1-5</sup> At least a 24-hour delay following insertion has been considered as the minimum period for conventional amalgams to attain adequate physical properties before such restorations could be polished effectively. The faster setting time and the earlier rate of development of high compressive strength of the newer "high copper" dental amalgams support the possibility that earlier finishing and polishing may be possible without significant detriment to the final restoration.<sup>6,8</sup>

While few clinicians appear to dispute the merits of finishing and polishing of amalgam restorations, the most practical time following placement remains unresolved. It is the purpose of this investigation to compare clinically the effects of early polishing of "high copper" dental amalgam restorations at an interval of eight minutes following the trituration of the amalgam with those observed after finishing and polishing at the more conventional time of at least twenty-four hours.

### Methods and Materials

Thirty-three patients, age 7-13 years, who demonstrated a total of 66 contralateral pairs of Class I occlusal cavities and 30 contralateral pairs involving buccal or lingual pits or grooves were selected. Mesio-occlusal and disto-occlusal surfaces on the maxillary molars were considered as separate pairs, but were designated for the same polishing variable in the study due to problems of isolation of the polishing agents in a small area. The restorations were designated for either immediate polishing at eight minutes or polishing at 24 hours after the start of trituration by following a randomized numerical chart for right or left and then adjusting for the last

pairs in order to obtain equal numbers of right and left immediate-polish pairs.

Selected teeth were anesthetized with 2% Carbocaine (Mepivacaine) containing 1:20,000 Neo-Cobefrin vasoconstrictor, isolated with a rubber dam, and Class I occlusal preparations were performed by three operators with a #56 fissure bur utilizing a high speed handpiece. Deep caries were removed with the appropriate size round bur in a contra-angle slow speed handpiece. The cavity was refined with a #57 fissure bur in a slow speed. After debridement of the cavity, varnish was applied with a small cotton pellet. The amalgam was triturated with an S.S. White Capmaster amalgamator,<sup>a</sup> according to manufacturer's specification for regular set Tytin amalgam<sup>b</sup> (800 mg). Condensation of the amalgam was mainly accomplished with a 1.4 mm round condenser and overpacked with a 1.4 mm x 2.0 mm elliptical shaped condenser using hand pressure.

### Carving Procedure

Immediately following condensation, the amalgam was burnished with a #21B anatomical burnisher<sup>c</sup> and carved with the cleoid end of a 7C cleoid/discoid carver<sup>d</sup> for good definition of the enamel-amalgam margin and occlusal pattern. A 5C cleoid/discoid carver<sup>e</sup> and an S.S. White #3 explorer<sup>f</sup> were used for refinement and for removal of flash at the margin. All amalgams were packed and carved during an interval of eight minutes from the start of trituration of the amalgam.

### Polishing Technique

Marginal adaptation, anatomic form, surface texture, occlusal morphology and recurrent caries were selected as the criteria to clinically compare the two methods of finishing and polishing utilized in this investigation. The first method of polishing was accomplished at the operative appointment eight minutes from the start of trituration of the amalgam for one restoration of each pair. A creamy paste of Silex XXX<sup>g</sup> and water on an unwebbed black rubber cup in a slow speed contra-angle handpiece was applied to the tooth for a period not to exceed one minute per surface. The second method was designated that the other contralaterally paired tooth be finished and polished after twenty-four hours. Pear-shaped finishing burs of decreasing size were run along the enamel-amalgam margin utilizing slow speed. Grooves were refined with a #0 round finishing bur by carrying the bur from the enamel-amalgam

margin into the center of the amalgam. Any extremely small grooves were finished with a #0 flame-shaped bur. The amalgams were then highly polished with a creamy paste of XXX Silex and water on an unwebbed black rubber cup with slow speed, followed by a creamy paste of tin oxide<sup>h</sup> and water.

### Evaluation

Evaluation of the two techniques of finishing and polishing amalgam was accomplished by two methods. The first method of analysis was a clinical examination based upon a Modified Ryge Explorer examination.<sup>9-11</sup> A qualitative visual clinical assessment was made utilizing a #4 mirror and an S.S. White #3 explorer by the three independent evaluators. The criteria for evaluation included: margin adaptation, anatomic form, surface texture, occlusal morphology, and caries (Tables 1-3). The teeth were examined at the baseline examination (at

Table 1. Criteria for quality evaluation.

<i>Marginal Adaptation (Dry)</i>	<i>Modified Rating</i>	<i>Health Center Criteria</i>
Restorative material is continuous with adjacent tooth structure — not detectable with a sharp explorer, passes in either direction	1	Alfa
Margin detectable by explorer examination only — along less than 50% of exposed margin	2	Alfa
Margin detectable by explorer examination only — along more than 50% of exposed margin	3	Alfa
Visible evidence of crevice formation into which the explorer will penetrate along less than 50% of exposed margin	4	Bravo
Visible evidence of crevice formation into which the explorer will penetrate along more than 50% of exposed margin	5	Bravo
Crevice formation with exposure of underlying dentin or base	6	Charlie

<sup>a</sup>S.S. White Division of Pennwalt Corp., King of Prussia, PA.

<sup>b</sup>S.S. White Dental Products International, Holmdel, NJ.

<sup>c</sup> <sup>d</sup> <sup>e</sup>E. F. Wessler Manufacturing Co., Cleveland, OH.

<sup>f</sup>S. S. White Division of Pennwalt Corp., Philadelphia, PA.

<sup>g</sup>Moyco Industries, Inc., Philadelphia, PA.

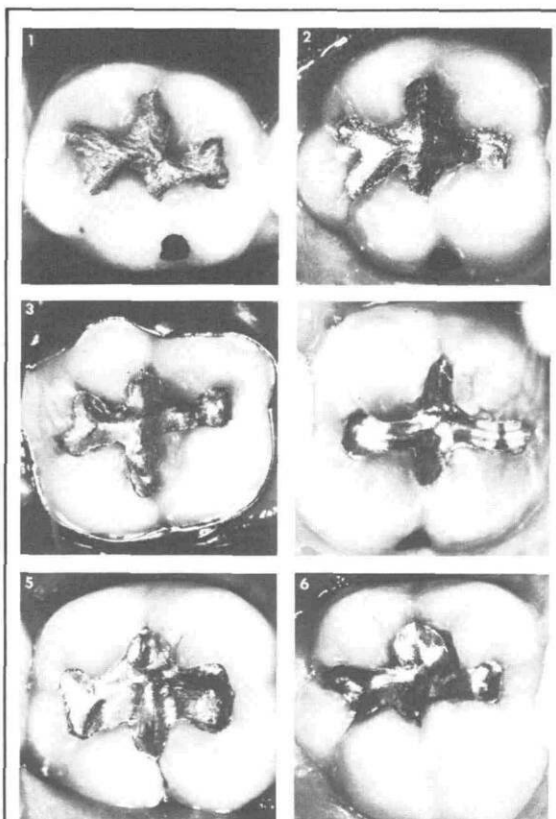
<sup>h</sup>Matheson, Coleman & Bell, Norwood, OH.

**Table 2.** Criteria for quality evaluation.

<i>Surface Texture</i>	<i>Rating</i>
Glossy	1
Satiny	2
Granular	3
Dull	4
Voids, pits, or scratches present — less than 50% exposed area	5
Voids, pits, or scratches present — more than 50% exposed area	6
Evidence of dark discoloration	7

least 24 hours after placement of the restoration) and at 6-, 12-, and 18-month recall appointments.

The second method of analysis was a modification of that developed by Mahler et al.<sup>12</sup> which compared the marginal adaptation from photographs of each restoration to photos of six representative restorations depicting specific stages of amalgam failure<sup>13</sup> (Figure 1 and Table 2). Additionally, the second step in the evaluation of the margins from the photos was



**Figure 1.** Photographic evaluation (See Table 1) (6x).

used to assess the amount of marginal flash: Category 1 — no flash; Category 2 — one or two areas of flash; Category 3 — three or four flash areas; and Category 4 — more than 4 flash areas.

Black and white photographs were taken at the baseline examination and at 6-, 12-, and 18-month recall appointments with a Medical Nikkor C camera

**Table 3.** Criteria for quality evaluation.

Anatomic Form	Rating
Harmonious and continuous with occlusal morphology — no change from original anatomic form	1
Evidence of loss of material from original anatomic form in one local area	2
Evidence of loss of material from original anatomic form in multiple areas	3
Loss of material with exposure of underlying dentin or base (designate surface number)	4
Total loss of all material or fracture of restoration	5
Occlusal Morphology	Rating
Harmonious and continuous with existing cuspal inclines — central pits and fissures well defined	1
Slightly discontinuous with existing cuspal inclines or central pits and fissures not well defined	2
Occlusal morphology not continuous and harmonious with existing cuspal inclines — central pits and fissures poorly defined or not evident	3
Caries Formation	Ratings
No caries associated with treated surfaces	1
Secondary caries related to treated surfaces	2
Replacement of material due to nonrelated caries	3

with a 200 mm macro lens set at 1.5x and enlarged 6x for evaluation. The baseline examination was performed at least 24 hours after placement of restoration in order to complete the conventional finishing and polishing method and to obtain sufficient strength to restorations polished at eight minutes.

A consensus was reached for each evaluation when at least two examiners agreed independently on the same rating for each clinical and photographic evaluation. When no agreement occurred following independent evaluation, a consensus was reached by re-examination and consultation by the three examiners. As a check on the consensus method of evaluation, 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<sup>9</sup> rating scale, and interexaminer agreement was calculated for both methods.

Recall examinations will continue to be completed

every six months for a period of three years. At each appointment, the recall procedures, except the fluoride treatment, will be completed prior to securing the necessary photographs and the explorer examinations. The recall procedures to be accomplished are: posterior bitewing radiographs, prophylaxis, oral examination, and a fluoride treatment. Any newly decayed teeth not involved in the study will be referred to the regular pedodontic clinic for restoration.

## Results

Initially, 96 pairs of amalgam restorations were evaluated independently at the baseline appointment by each investigator with a mirror and explorer for five criteria, and two criteria were evaluated from photographs of the restorations (Tables 1-3). Subsequently, at the 6-, 12-, and 18-month recall appointment, the numbers of pairs of restorations evaluated were 90, 85, and 81 respectively.

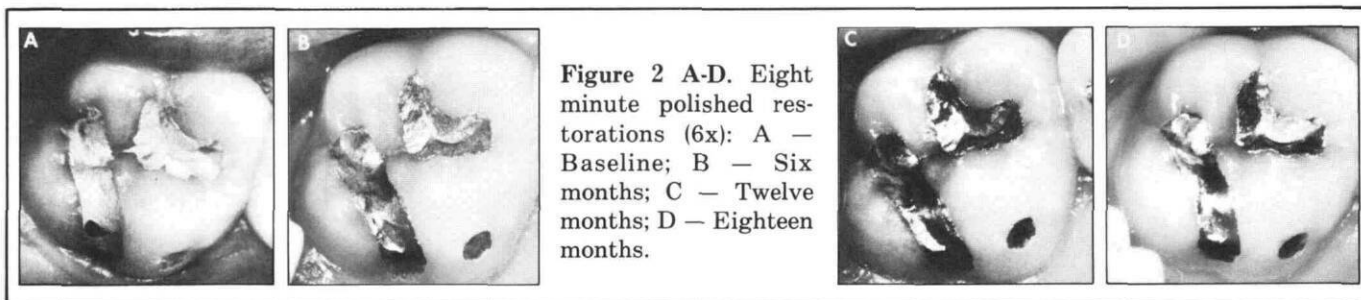
**Table 4.** Consensus ratings for criteria of quality evaluation.

Criteria	<i>Clinical Evaluation</i>							
	<i>Baseline</i>		<i>6 Months</i>		<i>12 Months</i>		<i>18 Months</i>	
	8 Min	24 Hr	8 Min	24 Hr	8 Min	24 Hr	8 Min	24 Hr
	$\bar{X} \pm S.D.$	$\bar{X} \pm S.D.$	$\bar{X} \pm S.D.$	$\bar{X} \pm S.D.$	$\bar{X} \pm S.D.$	$\bar{X} \pm S.D.$	$\bar{X} \pm S.D.$	$\bar{X} \pm S.D.$
Marginal Adaptation	1.58 ± .49	1.66 ± .48	1.96* ± .47	1.96* ± .44	2.00 ± .31	2.03 ± .32	2.12* ± .36	2.14* ± .44
Surface Texture	3.97 ± .31	1.06 ± .43	2.89* ± .66	2.12* ± .74	2.76* ± .57	1.94* ± .44	2.50* ± .57	2.04 ± .46
Anatomic Form	1.09 ± .29	1.03 ± .17	1.07 ± .25	1.08 ± .27	1.20 ± .43	1.10 ± .31	1.01 ± .11	1.01 ± .11
Occlusal Morphology	1.10 ± .31	1.21 ± .41	1.06 ± .23	1.04 ± .21	1.05 ± .21	1.05 ± .21	1.04 ± .19	1.00 ± .00
Caries	1.00 ± .00	1.00 ± .00	1.00 ± .00	1.00 ± .00	1.00 ± .00	1.00 ± .00	1.00 ± .00	1.00 ± .00
	<i>Photographic Evaluation</i>							
Marginal Adaptation	1.32* ± .49	1.93 ± .39	2.02* ± .52	2.47* ± .60	2.44* ± .73	2.70* ± .55	2.56 ± .69	2.71 ± .53
Flash	2.02* ± .75	1.70 ± .54	1.84* ± .65	1.77 ± .60	1.86 ± .65	1.82 ± .56	1.80 ± .66	1.79 ± .51

\*Significant difference ( $p < 0.05$ ) in restorations polished by the same method for two time periods.

°Significant difference ( $p < 0.05$ ) in restorations polished by the two methods at one time period.

Statistical test: Michigan Interactive Data Analysis System (MIDAS: Paired t-test)



**Figure 2 A-D.** Eight minute polished restorations (6x): A — Baseline; B — Six months; C — Twelve months; D — Eighteen months.

Our consensus agreement for all clinical evaluations averaged 98% for marginal adaptation compared to 96% when the ratings were converted to the Dental Health Center scale (Table 1). The consensus agreement for surface texture was 97%. Additionally, the consensus agreement among examiners from the photographic evaluations of marginal adaptation and flash exhibited a range of 94-99% and 93-98% respectively.

From baseline to the 18-month evaluation, there was no significant difference ( $p < 0.05$ )\* between restorations polished at 8 minutes and 24 hours, nor between each method at the various time intervals for anatomic form, occlusal morphology, and caries formation (Table 4). Conversely, a significant difference was initially obvious in surface texture between restorations polished at 8 minutes and 24 hours (Tables 4 and 5). At baseline, the eight minute restorations appeared uniformly granular with a dull finish (Figure 2A), whereas restorations polished at 24 hours exhibited a shiny, reflective surface (Figure 3A). Although the significant difference in surface texture between restorations polished at 8 minutes and those at 24 hours persisted throughout the study, by 18 months the granularity of the restorations polished at 8 minutes had decreased markedly (Tables 4 and 5), and the difference in the appearance in the surface texture between the two methods had narrowed enough that many pairs of restorations demonstrated a similar appearance at 18 months (Figures 2D and 3D).

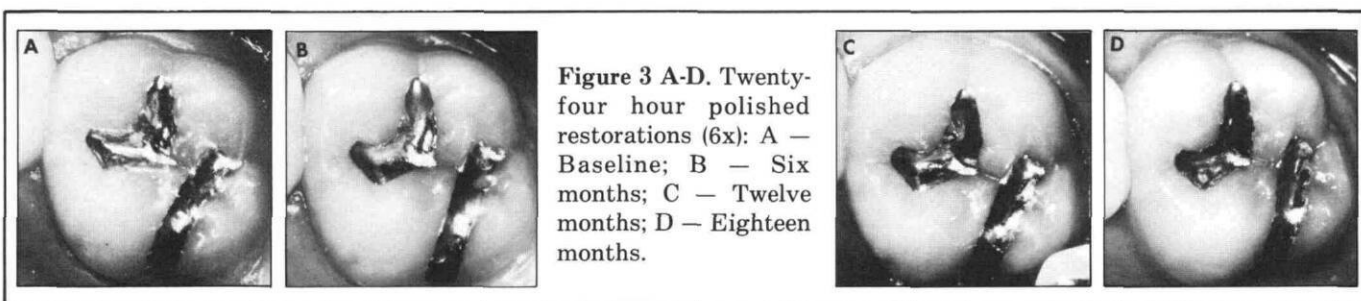
The clinical evaluation of marginal adaptation revealed no significant differences between the two \*MIDAS (Michigan Interactive Data Analysis Systems); paired t-test.

methods of polishing at baseline nor during subsequent recall appointments throughout 18 months (Tables 4 and 6). However, the ratings for marginal adaptation progressively worsened for restorations polished at both 8 minutes and 24 hours, beginning at baseline and continuing through the 18-month recall (Table 6). Significant differences from prior ratings were observed at the 6- and 18-month recall appointments (Table 4).

The photographic evaluation of the marginal adaptation revealed that the margins for restorations polished at both 8 minutes and 24 hours gradually worsened from baseline to 18 months with significant differences between the two methods at baseline, 6-, 12-, and 18-months (Table 4). Additionally, the amount of flash observed for restorations polished at 24 hours was significantly less than the 8-minute restoration at baseline, but at subsequent recall intervals no significant differences were observed between the two methods (Tables 4 and 7).

## Discussion

The development of the high copper amalgams which are reported to be superior clinically to the conventional amalgams has led to their widespread use.<sup>14-19</sup> Their adoption has required changes in the habits of dentists in the manipulation and finishing of such new alloys. The polishing of high copper amalgam restorations shortly after insertion has been postulated from the results of a variety of laboratory investigations,<sup>8,14,20</sup> based upon the assumption that the improved physical properties of the high copper amalgams (i.e., low static and dynamic creep, early high and final compressive strength, faster rate of hardening, and eliminated



**Figure 3 A-D.** Twenty-four hour polished restorations (6x): A — Baseline; B — Six months; C — Twelve months; D — Eighteen months.

Rating	Baseline		6 Months		12 Months		18 Months	
	8 Min	24 Hr	8 Min	24 Hr	8 Min	24 Hr	8 Min	24 Hr
Number	96	96	89	91	85	86	82	81
1 — Glossy	1	94	2	8	-	10	2	6
2 — Satiny	-	-	13	70	26	72	38	67
3 — Granular	-	-	71	10	53	3	41	7
4 — Dull	95	2	3	3	6	1	1	1

**Table 5.** Clinical consensus ratings for surface texture.

gamma-2 phase) would provide the resulting amalgam restoration with properties adequate to withstand the effects of early polishing while enhancing the surface texture and marginal adaptation. Busquets et al.<sup>14</sup> demonstrated the effects of early finishing and polishing of amalgam restorations using the scanning electron microscope, and observed that finishing burs should not be used on 8-minute amalgams, whereas carefully carved high copper restorations followed immediately by polishing produced a restoration with acceptable surface texture and favorable marginal adaptation.

Nitkin and Goldberg<sup>8,20</sup> examined the effects of early polishing of a variety of amalgams and postulated that restorations of high copper amalgam could be polished at the time of placement, but suggested that the time of polishing varied with the individual alloy. We selected 8 minutes after trituration of regular set Tytin amalgam as a feasible, yet practical period at which newly inserted amalgam restorations could be polished without detriment to the structures of the restoration. Additionally, 8 minutes appeared to be a reasonable time to allow for the insertion and carving of a quadrant of newly placed, regular set restorations by an experienced dentist.

The benefits of polished amalgam restorations over those which remained unfinished following carving have been suggested by a variety of investigators,<sup>1,5</sup> generally without the benefit of qualitative longitudinal clinical comparison of such restorations. In order to compare the effects of early polishing to those resulting from conventional polishing methods, the most precise methods available were modified and utilized for the present investigation. The clinical serviceability of the amalgam restorations is generally defined in terms of marginal integrity which was evaluated clinically in this study using a modification of the method reported by Ryge and Snyder<sup>9</sup> in 1973. Their criteria for the assessment of margin adaptation (Table 1) was further subdivided

to allow for identification of the gradual marginal changes observed to occur prior to marginal crevice formation or recurrent decay<sup>11</sup> (Table 1). This method of evaluation assumes significant relevance to clinicians since the decision to replace restorations is based upon evidence derived by clinical examination.

Similar criteria used for clinical evaluation were subsequently applied to the photographic evaluation of marginal adaptation using a modification of the method by Mahler et al.<sup>12</sup> In comparing the clinical and photographic evaluations of marginal adaptation, the results of both methods of evaluation demonstrated that all marginal ratings gradually worsened from baseline to 18 months, although the greatest decrement occurred during the first six months (Figures 2A-D and 3A-D). The statistical differences between the two polishing methods observed from the photographic evaluation appeared due to the much higher magnification (6x) of the photographs utilized as compared to the visual and explorer phases of the clinical examination.

The early polishing of restorations produced marginal adaptation similar to those polished at 24 hours, with the polish at 8 minutes requiring considerably less time. At 8 minutes the amalgam is not completely set, allowing further refinement of the margins after carving with the careful application of a polishing agent. We consider the success of the restorations polished at 8 minutes to be contingent upon a careful carving method whereby all possible marginal excesses are removed prior to polishing. Even though more flash was evident photographically up to 6 months with the restorations polished at 8 minutes, the subsequent loss of such flash did not prove detrimental, leading to the speculation that any flash observed following the polishing at 8 minutes was very thin and its loss did not cause significant marginal voids (Figures 2A-D).

One of the problems with early polishing is the resultant granular surface texture which would possibly allow for greater plaque accumulation than

Table 6. Marginal ratings for clinical and photographic evaluation.

Rating	<i>Clinical Evaluation</i>							
	<i>Baseline</i>		<i>6 Months</i>		<i>12 Months</i>		<i>18 Months</i>	
	8 Min	24 Hr	8 Min	24 Hr	8 Min	24 Hr	8 Min	24 Hr
N	96	96	90	91	85	86	82	81
1 — Alpha	40	33	10	10	3	2		1
2 — Alpha	56	63	76	76	80	80	73	70
3 — Alpha			2	4	1	3	8	8
4 — Beta			2	1	1	1	1	2
5 — Beta	No Ratings _____							
6 — Charlie	No. Ratings _____							
<i>Photographic Evaluation</i>								
N	93	95	90	91	85	86	82	82
1	64	11	10	1	2	1	2	1
2	28	80	69	50	49	27	38	24
3	1	4	10	36	29	55	37	55
4			1	4	3	3	4	2
5					2		1	
6	No Ratings _____							

the smoother, conventionally polished restorations. In this study, though plaque accumulation was not measured, increased plaque around the restorations polished early as compared to the restorations polished at 24 hours was not readily evident at the recall appointments. Also, in this study there was no recurrent decay along the margins, so new interproximal decay involving the pairs of teeth studied, and no restorations of either the groups polished at 8 minutes or those at 24 hours were judged clinically unacceptable at 18 months. Additionally, there was clearly an improvement in the surface texture such that by 18 months, many restorations polished at 8 minutes approached the surface texture of their paired restorations polished at 24 hours (Table 5). This effect was noticeable on the occlusal surfaces where direct self-polishing from mastication was most effective, but future investigations should be conducted to evaluate plaque retention on the

granular texture of a proximal surface after early polishing.

Final adoption of the early polishing method for amalgam restorations in occlusal fissures and smooth surface pits should await continued longitudinal assessment of this method.

### Conclusions

In a controlled study, the marginal adaptation of pit and fissure restorations of a high copper amalgam (Tytin) worsened from baseline to 18 months for restorations polished at either 8 minutes or 24 hours after placement. Clinically, there were no significant differences between the marginal adaptation of restorations polished by the two methods. However, a significant difference in marginal adaptation was evident by photographic evaluation. At baseline the surface texture of restorations polished at 8 minutes was granular compared to the glossy surface of

Table 7. Consensus of areas of flash from clinical evaluation.	Baseline		6 Months		12 Months		18 Months	
	8 Min	24 Hr	8 Min	24 Hr	8 Min	24 Hr	8 Min	24 Hr
(N)	93	96	90	91	85	86	82	82
<i>Areas of Flash</i>								
None	20	32	25	29	22	23	24	21
1-2	56	59	56	54	54	56	53	57
3-4	12	4	7	8	7	7	2	4
More than 4	5	-	2	-	2	-	3	-

restorations polished at 24 hours, but by 18 months the surface texture of restorations polished by the two methods were similar. Additional data will be collected through the remaining 18 months of the study.

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