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Comparison of dental student silver soldering using an orthodontic blowpipe or Hydroflame®[a]

James T. Barenie, DDS, MS
David R. Myers, DDS, MS
Paul J. Krautmann, DDS

Abstract

This study compared fabrication of silver solder joints by dental students using an orthodontic blowpipe or a Hydroflame ® soldering unit. Fifty-eight students attended a lecture and observed demonstrations of silver soldering. Thirty students used a Hydroflame ® to prepare one practice solder joint and two technique solder joints. These students then prepared one practice solder joint and two technique joints utilizing the blowpipe. The remaining 28 students prepared similar solder joints but the orthodontic blowpipe was used prior to the Hydroflame ®. Solder joints were evaluated by the students and an independent examiner for amount of solder applied, contour of joints, and amount of surface porosity and oxidation. Solder joints prepared with the Hydroflame ® had significantly higher ($p < .03$) evaluations for contour (2.34 -2.85 vs. 1.88 -2.57) and amount of solder utilized (2.39 -2.90 vs. 1.93 -2.48). No significant difference was found in the amount of surface oxidation or porosity between techniques.

Silver solder can be applied using several techniques. One method involves the production of heat with a natural gas and compressed air mixture in the orthodontic blowpipe.[1,2,3] An electrosoldering technique creates high temperatures at a carbon tip and minimizes the area heated.[4,5] An indirect technique relies on production of heat by a gas-air flame or electricity and conveyance of heat to the workpieces through an intermediate material such as brass wire.[6] Another technique utilizes the Hydroflame® device which electrolytically generates hydrogen and oxygen for combustion in a well-focused flame.

Studies have compared silver solder joints produced by various methods.[4,6] Gardiner and Aamodt compared the gas-air flame, a plain gas flame, a gas-air flame heated brass wire, an electrically heated brass wire, and the electrosoldering technique.[6] Their results indicated that the strongest joints and the least annealing were produced by the gas-air flame heated brass wire. Laird and von Fraunhofer compared the gas-air flame and electrosoldering techniques.[4] They found no significant differences between the tensile strength or microhardness of the joints produced by either method. A recent investigation by Brown et al. indicates that the Hydroflame® can produce solder joints with tensile strengths equivalent to or slightly higher than those produced with other techniques.[7]

Dental students at the Medical College of Georgia traditionally had been taught to use the orthodontic blowpipe in a pedodontic technique course; however, faculty found that students had difficulty mastering this technique. The purpose of this study was to determine the soldering technique preferred by dental students and to compare the quality of silver solder joints fabricated by dental students using an orthodontic blowpipe or a Hydroflame.®

Methods and Materials

Fifty-eight second-year dental students with no previous experience in dental soldering procedures attended a one-hour lecture describing silver soldering techniques with the orthodontic blowpipe and the Hydroflame®. The lecture included: properties of stainless steel and silver soldier; the importance of cleanliness; contact between workpieces; control of heat; model and hand stabilization; application of flux; use of the orthodontic blowpipe and Hydroflame®; and the appearance, size and contour of ideal solder joints.

In groups of six to eight, all students observed demonstrations of each soldering technique by the same skilled operator. Major points of the soldering lecture were reinforced during the demonstrations, questions were answered, and the samples of solder joints with a quality range of excellent to poor were displayed. At this time students were divided randomly into two groups. Students in Group A (N = 30) would first fabricate solder joints with the Hydroflame®, then with the blowpipe (Figure 1). Students in Group B (N = 28) would first prepare solder joints using the blowpipe, then with the Hydroflame®.

Three students at a time from Group A came to an isolated area of a laboratory to perform soldering pro-

[a] Hydroflame II Precision Soldering Unit, Unitek Corp., Monrovia, Calif.

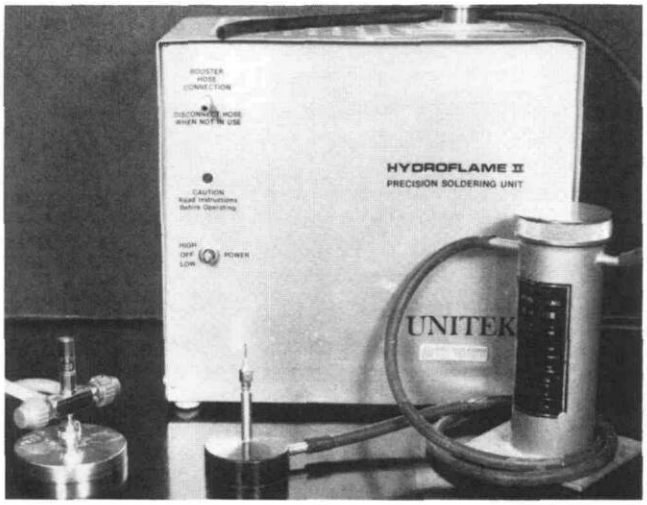

Figure 1. The orthodontic blowpipe and Hydroflame® unit.

nique. Fifty percent felt that the Hydroflame® technique was easier to learn, while only 9% felt that the blowpipe technique was easier to learn. Seventy-one percent responded that the Hydroflame® was easier to use, while only 9% felt that the blowpipe was easier to use. Sixty-six percent of the students felt that better solder joints were produced with the Hydroflame®, while only 17% felt that better solder joints were produced with the blowpipe. The differences between the students who favored the Hydroflame® and those who favored the blowpipe in questions 3–5 were significant at the .01 level.

Evaluations of the solder joints by the independent examiner are summarized in Table 2. Mean scores for surface porosity were similar with both techniques and ranged from 3.85 to 4.00. Mean scores for surface oxidation were also similar with both techniques and ranged from 2.82 to 3.38. Since minimal variance occurred between scores for surface porosity or oxidation using either technique, further analysis of this data was not indicated.

Mean scores for contour using the Hydroflame® ranged from 2.34 to 2.85, while mean scores using the blowpipe were lower and ranged from 1.88 to 2.57. Mean scores for amount of solder used were also higher with the Hydroflame®, ranging from 2.39 to 2.90, while mean and surface porosity were each evaluated using prepared standards which demonstrated the following degrees of quality: 0 — no solder joint, 1 — poor, 2 — fair, 3 — good, 4 — excellent. An independent examiner, who was unaware of which technique had been used, subsequently evaluated all solder joints on three separate occasions at monthly intervals using the same rating scale and standards.

Results

Results of the questionnaire are shown in Table 1. Most of the students felt competent using either techcedures. They again were shown ideal solder joints and directed to attempt fabrication of solder joints of similar quality. Each student was given a practice model on which a stainless steel band and wire were stabilized in place. Flux[b] was applied and a practice solder joint was prepared by each student using the Hydroflame® and spooled silver solder.[c] After fabrication of the practice solder joint, students were given a coded model which had two molar bands adapted and pieces of .036" stainless steel wire stabilized on the buccal and lingual of each band (Figure 2). The Hydroflame® was used to first make a buccal and then a lingual solder joint on one side of the model. The students again were given the practice model and they prepared a solder joint using the orthodontic blowpipe. After completion of the practice technique the students were instructed to produce high-quality solder joints on the opposite side of the coded model using the orthodontic blowpipe.

Students in Group B prepared solder joints using a similar protocol except soldering was accomplished first with the orthodontic blowpipe, and then with the Hydroflame®.

Upon completion of soldering procedures, each student completed a questionnaire on technique preference and then evaluated each of his four technique solder joints. The contour, amount of solder, surface oxidation, scores with the blowpipe ranged from 1.93 to 2.48. A multivariate analysis of variance indicated that Hydroflame® mean scores were significantly higher ($p < .03$) than blowpipe mean scores for contour and amount of solder. No significant effect was found due to the order in which the techniques were used, nor was the group-order interaction significant.

A univariate analysis of variance indicated that the mean scores for contour and amount of solder were significantly higher ($p = .05$–$.01$) for the joints produced using the hydroflame® first than were the mean scores attained when the blowpipe was used first. Similarly, solder joints produced by students using the Hydro-

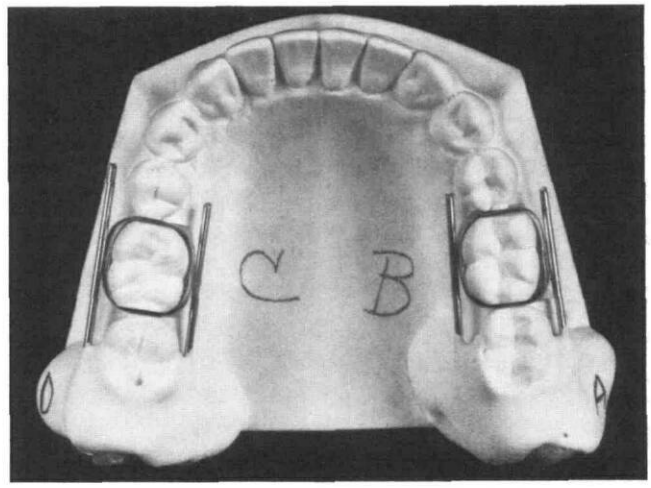

Figure 2. Coded working model with stainless steel bands and wires positioned.

[b] Unitek Soldering Flux, 700-202, Unitek Corp., Monrovia, Calif.
[c] Unitek Silver Solder Formula-6 700-103, Unitek Corp., Monrovia, Calif.

Table 1. Results of Questionnaire

		Yes	No
Do you feel competent to use the orthodontic blowpipe?		90%	10%
Do you feel competent to use the Hydroflame®?		95%	5%
	Hydroflame®	Orthodontic Blowpipe	No Difference
Which technique was easier to learn?	50%	9%	41%
Which technique was easier to use?	71%	9%	21%
Which technique produced better solder joints?	66%	17%	17%

Table 2. Evaluation of Solder Joints By Independent Examiner

	Group A Mean Scores	S.D.		Group B Mean Scores	S.D.
		Porosity			
H-1	4.00	.00	OB-1	3.86	.76
H-2	3.97	.13	OB-2	3.96	.13
OB-1	3.85	.73	H-1	3.96	.19
OB-2	3.85	.42	H-2	3.96	.16
		Oxidation			
H-1	3.07	.73	OB-1	2.82	.82
H-2	3.07	.73	OB-2	3.38	.55
OB-1	3.07	.82	H-1	3.27	.70
OB-2	3.00	.63	H-2	2.93	.82
		Contour			
H-1	2.35	.98	OB-1	1.88	.83
H-2	2.85	1.04	OB-2	2.21	.93
OB-1	2.18	1.14	H-1	2.34	.94
OB-2	2.57	1.00	H-2	2.75	.97
		Amount of Solder			
H-1	2.50	.87	OB-1	1.93	.87
H-2	2.90	.93	OB-2	2.27	.94
OB-1	2.20	.91	H-1	2.39	.95
OB-2	2.48	.83	H-2	2.71	.93

H-1 = buccal solder joints made with Hydroflame®
H-2 = lingual solder joints made with Hydroflame®
OB-1 = buccal solder joints made with orthodontic blowpipe
OB-2 = lingual solder joints made with orthodontic blowpipe

flame®, after their previous experience with the blowpipe, had higher mean scores for contour and amount of solder than did joints produced by students using the blowpipe, after their previous experience with the Hydroflame®. However, these differences were not statistically significant.

The correlation coefficients between student self-ratings of solder joints and the independent examiner ratings ranged from .06 to .53, indicating low to moderate agreement. The independent examiner's evaluations were lower than students' evaluations for contour, amount of solder and oxidation, and higher than students' evaluations for porosity. Correlations to determine intrarater reliability of the independent examiner produced values of .87 for contour and .82 for amount of solder. These were sufficiently high correlations to support the consistency of the independent examiner.

Discussion

A majority of the students indicated that the Hydroflame® technique was easier to learn, easier to use, and produced better solder joints. Discussion with students indicated a degree of frustration in adjusting the blowpipe flame and some difficulty in determining the correct portion of the blowpipe flame to use. Since the Hydroflame® requires no flame adjustment and produces a well-focused flame, it was favored by the students. The ease of handling the Hydroflame® torch stand as opposed to the blowpipe also was reported.

Students were able to produce solder joints with more ideal contours and solder amounts with the Hydroflame®. A strong positive correlation between contour and amount of solder utilized exists since the proper contour of a solder joint cannot be attained unless the proper amount of solder is used. Most solder joints judged fair or poor in contour or amount of solder resulted from insufficient solder. Little surface porosity or oxidation was observed with either technique.

Although the students and the independent examiner used the same standards as aids in evaluating solder joints, only low to moderate correlations were found between the students' and examiner's evaluations. While it was thought that sufficient exposure to concepts of ideal solder joints had been given, more experience is needed, evidently, before students are able to make proper evaluations.

Conclusion

This data indicates that dental students preferred the Hydroflame® technique and that the contour and amount of solder in joints produced with the Hydroflame® were significantly better than those produced using the orthodontic blowpipe.

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Dr. Barenie is professor and director, Pedodontic Postgraduate Program, and Dr. Myers is professor and chairman, Department of Pedodontics, Medical College of Georgia, School of Dentistry, Augusta, Ga. 30912. Dr. Krautmann is in private practice of pedodontics, 258 Court St., Keene, N.H. 03431.

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