Microleakage comparison of amalgam-composite interface and dentin-composite interface, the two surfaces formed during the defective amalgam margin repairs with bulk-fill resin composite

By

Sung S. Kim

A THESIS

Submitted in partial fulfillment of the requirements for the degree of Master of Science in the Department of Oral Biology in the Uniformed Services University of Health Sciences
FORT BRAGG, NC
2017

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MICROLEAKAGE COMPARISION OF AMALGAM-COMPOSITE INTERFACE AND DENTIN-COMPOSITE INTERFACE, THE TWO SURFACES FORMED DURING THE DEFECTIVE AMALGAM MARGIN REPAIRS WITH BULK-FIL RESIN COMPOSITE

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Submitted by Sung S Kim in partial fulfillment of the requirements for the degree of Master of Science in Oral Biology.
Accepted on behalf of the Faculty of the Graduate School by the thesis committee:

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Protocol Number: 1
Principal Investigator: S. Kim
Protocol Title: Microleakage comparison of amalgam-composite and dentin-composite interface
Initial Date Submitted: 10JAN2016
Revision Date:

Request for Determination for Research Meeting the Criteria for Research Not Involving Human Subjects (RNIHS)

1.0 PROTOCOL TITLE: Microleakage comparison of amalgam-composite interface and dentin-composite interface, the two surfaces formed during the defective amalgam margin repairs with bulk fill composite

2.0 PRINCIPAL INVESTIGATOR:

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2.1 OTHER INVESTIGATORS: N/A

3.0 RESEARCH NOT INVOLVING HUMAN SUBJECTS DETERMINATION Please double click on the box that applies to your research and mark the "check" box.

3.1. Is the activity a **systematic** investigation **designed** to develop or contribute to **generalizable** knowledge? 32 CFR 219.102(d) *Generalizable knowledge consists of theories, principles, or relationships (or the accumulation of data on which they may be based) that can be corroborated by accepted scientific observation and inference that is applicable to other related situations, populations, or devices outside of the tested situation.*

☐ No. Activity is not research and does not require Clinical Investigation Service oversight.

☒ Yes. Proceed to 3.2. Because you are making a request for Research Not Involving Human Subjects determination, this should be checked "yes."

3.2 Does the research involve obtaining information about living individuals? 32 CFR 219.102(f)

☒ No. Activity is Research Not Involving Human Subjects. *Cadaver studies or animal studies would fall into this category.*

☐ Yes. Proceed to 3.3. This would almost always be checked "yes."

3.3. Does the research involve **intervention** or **interaction** with the individuals? 32 CFR 219.102(f). Intervention or interaction is some form of contact with the study subject.

☐ Yes. Activity is Human Subjects Research. Please contact usarmy.bragg.medcom-wamc.list.wamc-irb-admin@mail.mil for further instructions. You will have to submit

your proposal as an "exempt" protocol or standard protocol application.
☒ No. Proceed to 3.4.

3.4. Though you are not interacting or intervening with a living individual, you will be using their information. Is this information individually identifiable by the research team at any time?
☒ No. **Activity is Research Not Involving Human Subjects** and therefore does not require IRB approval. *This is the box that you will most likely check.*
☐ Yes. Proceed to 3.5.

3.5. Is the information private? 32 CFR 219.102(f)
☐ Yes. Activity is Human Subjects Research. Please contact usarmy.bragg.medcom-wamc.list.wamc-irb-admin@mail.mil for further instructions. You will have to submit your proposal on an "exempt" protocol or standard protocol application.
☒ No. **Activity is Research Not Involving Human Subjects** and therefore does not require IRB approval. *This would be information that is available in the public domain.*

4.0 EXPECTED COMPLETION DATE FOR STUDY (INCLUDING DATA ANALYSIS): April 2017

5.0 SUMMARY: To compare microleakage of amalgam-composite and tooth-composite interfaces, two surfaces formed and bonded during defective amalgam repair using Bulk-fill composite.

5.1 DATA COLLECTION METHODOLOGY AND STATE THE STUDY

24 extracted human molars will be used for this research project: Prepared for two occlusal(O) cavities – each has approximately 2.7mm(W)X2.7mm(L)X2.7mm(H) dimension ; first cavity will be prepared and filled with amalgam initially; one day later, the second cavity will be prepared and filled to simulate a "clinical repair" using two different resin composite materials: 12 Bulk-fill composite(SDR) restoration sample as test group vs. 12 packable resin composite(TPH) restoration sample as a control group. All samples will be stored in the distilled water at 25 degree Celsius for 60 hours, then they will be placed in methylene blue dye solution for one hour; the samples will be sectioned with slow speed isomet saw, and dye penetrations will be assessed and compared at amalgam-composite interface and tooth-composite interface for both test and control groups.

5.2 DESCRIBE THE TYPE OF DATA OR SPECIMENS TO BE STUDIED: Extracted molar teeth with amalgam restoration and composite repair.

5.3 NUMBER OF PARTICIPANTS: No participants will be utilized.

5.4 DESCRIBE ANY CODING OF DATA OR SPECIMENS, INCLUDING INFORMATION ON WHO HOLDS THE KEY TO THE CODE: No coding of Data.

5.5 MILITARY RELEVANCE: Army Service Members are very active and may only require a repair of a defective amalgam vs. replacing the whole restoration

5.6 MEDICAL APPLICATION: Bulk-fill composite is recently introduced, and there has been no study published for using it as an amalgam repair materials according to PudMed search engine.

6.0 PUBLICATION REQUIRMENTS: Proper WAMC publication clearance is required prior to all presentations, abstracts, and publications. The following require WAMC approval: reports involving WAMC subjects and/or patients, reports that cite WAMC in the title or byline, reports of WAMC approved clinical investigation or research, reports of research performed at WAMC, and reports of research conducted by WAMC assigned personnel.

The investigators will obtain proper OTSG publication clearance prior to all presentations, abstracts, and publications that involve traumatic brain injury, post-traumatic stress, poly-pharmacy, pain, or suicide.

The investigators must provide to the Department of Clinical Investigation a listing of presentations, abstracts, and publications arising from the study.

7.0 SIGNATURES:

I verify that the contents of this proposal are accurate and that I have read and agree to comply with the statements above which outline my responsibilities as a Principal Investigator.

Sung Soo Kim

Principal Investigator Signature
Name and Date: Sung S. Kim, 10JAN2016

Protocol Number: 1
Principal Investigator: S. Kim
Protocol Title: Microleakage comparison of amalgam-composite and dentin-composite interface
Initial Date Submitted: 10JAN2016
Revision Date:

6.1 OTHER SIGNATURES FOR APPROVAL:

I concur with the submission of this proposal to the Department of Clinical Investigation for review and approval.

Manuel Peláez, DMD, MS
Periodontist
Service Chief Signature
Name and Date: 10 JAN 16

STACY L. LARSEN, COL DC
Department Chief Signature
Name and Date: 10 Jan 16

Regulatory Affairs Review

10 JAN 2016
Name and Date Karen Gonzalez Torres, MAS, DC

Scientific Review

10 JAN 2016
Name and Date Karen Gonzalez Torres, MAS DC

Submitted by Sung S Kim in partial fulfillment of the requirements for the degree of Master of Science in Oral Biology.
Accepted on behalf of the Faculty of the Graduate School by the thesis committee:

Date	Manuel Pelaez, DMD Research Director
Date	Jason Bullock, DMD AEGD Assistant Director/Mentor
Date	Stacy Larsen, DDS AEGD Program Director/Mentor

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LIST OF ABBREVIATIONS

C-factor - Cavity configuration factor

SM – Steve Mark

AY – Anna Yoon

ACKNOWLEDGMENTS

I would like to express my sincere thanks to my AEGD Program Director/Mentor - COL Larsen, Assistant Director/Mentor - MAJ Bullock, Research Director - LTC Pelaez for their guidance, support, and assistance for my research project.

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ABSTRACT

Objective: To compare microleakage of amalgam-composite and tooth-composite interfaces, two surfaces formed and bonded during defective amalgam repair using Bulk-fill composite.

Materials and methods: 25 extracted human molars were used for this research project: Prepared for two occlusal(O) cavities – each has approximately 2.7mm(W)X2.7mm(L)X2.7mm(H) dimension ; first cavity was prepared and filled with amalgam initially; one day later, the second cavity was prepared and filled to simulate a "clinical repair" using two different resin composite materials: 13 Bulk-fill composite(SDR) restoration sample as test group vs. 12 packable resin composite(TPH) restoration sample as a control group. All samples were stored in the distilled water at 25 degree Celsius for 60 hours, then they were placed in methylene blue dye solution for one hour; the samples were sectioned with slow speed isomet saw, and dye penetrations were assessed and compared at amalgam-composite interface and tooth-composite interface for both test and control groups.

Results: Overall leakage scores for the tooth composite interface (Mdn = 0) were not significantly different than the amalgam composite interface (Mdn = 0). Among the tooth composite interface, the leakage score distributions did not significantly differ between TPH and Bulk-fill resin (Mann–Whitney $U = 66.00$, $P = 0.36$). In contrast, among the amalgam composite interface, a Mann-Whitney test indicated that the leakage score in the Bulk-fill group (Mdn = 0) differed from the TPH group (Mdn = 3), $U = 36.50$, $P = 0.02$

Conclusion: In vitro study demonstrates that Bulk-fill resin composite has less leakage score at

repaired amalgam to resin composite interface compared to traditional packable resin composite. Repair with flow-able type resin composite is conservative and evidence-based approach to treat defective amalgam restoration as long as the affective margins are relatively shallow and located in non-stress bearing area. Evaluating different methods and techniques for amalgam repairs are necessary in order to choose optimal treatment for patient's clinical circumstances and needs. Bulk-fill resin is viable material of choice for repairing the amalgam restoration, however, further bond strength tests, durability test, and clinical trials are needed to verify its long-term success and performance of material.

INTRODUCTION

STATEMENT OF THE PROBLEM:

Dental Amalgam has been used as a restorative material for many years in clinical dentistry and as a result, dentists frequently encounter patients with defective amalgam restorations. Traditionally complete replacement of the restoration has been seen as the ideal method to treat these cases. [1] However, alternative and more conservative approach, entails repairing the defective lesion if it is small and located in non-stress bearing surface.[2] In addition, repairs of restoration gain more popularity while repair technique are now being taught in most dental schools in Europe and North America.[3]

SIGNIFICANCE:

There are numerus methods and material options available for dentist to select particular repair and replacement of restoration.[3] Bulk-fill composite is recently introduced, and there has been no study published for using it as an amalgam repair materials according to PubMed search engine.

BACKGROUND AND LITERATURE REVIEWS

AMALGAM HISTORY:

In restorative dentistry Amalgam has been commonly used, especially in posterior region despite recent environmental regulation to that outlines the gradual phase down of human use of mercury.[4,5] The use of amalgam is still considered an important part of restorative treatment options because of low cost and long-term cost effectiveness.[3]

The main reason for replacing amalgam restorations are secondary caries and restoration fracture.[6] Recent article published in 2014 showed that 75% of the defective restorations were replaced and 25% were repaired.[7] In same study, most defects were amalgam (56%) and the most common repair material was composite resin (56%). In addition, larger retrospective cohort review of dental records from U.S. Navy and Marine Corps personnel evaluated the frequency of replacement for both posterior composite and amalgam restorations.[8] A total of 1050 restorations [565 Composite resin and 485 Amalgam] were followed in 247 patients for an average of 2.8 years. The overall replacement rate was 5.7% over this period, with no differences in replacement risk or rates between composite and amalgam materials.

However, all recent clinical trial results, comparing the clinical performance of amalgam and composite resin restoration, were consistent in that amalgam restoration showed a lower risk for failure and secondary caries although no differences were found in the risk for fracture between the two materials.[5]

AMALGAM REPAIR METHODS:

There are four possible options for treating defective amalgam restoration - repairing, sealing, refinishing, and replacement according to 7 year clinical study:[9]

Repair: *removal of the part of the restoration that is defective*

Sealing: *applying resin-based sealant on defective site of margin*

Refinishing: *using finishing burs to remove surface defects or excess amalgam*

Replacement: *removal of the entire restoration and replacement of a new restoration*

Though repairing amalgam restoration with amalgam is feasible, the use of resin-based composite to repair amalgam to be more suitable methods when a proper surface conditioning technique is applied; the best result of surface treatment was obtained when the amalgam samples were silica coated, followed by the use of a silane, a bonding agent and a resin based composite.[3] This technique is recommended in following sequences: 1) the amalgam surface should be silica coated first , 2) dentin and enamel should be etched, washed and rinsed thoroughly, 3) amalgam should be silanized and primer/bonding should be applied onto dentin.[4]

One study exhibited that roughing the surface using a #557 carbide burs yields higher repair strength than treating the surface with air abrasion(50 mm aluminum oxide) or Amalgambond Plus.[10] However, more recent in vitro study showed that there was no statistical difference between the microleakage values of surfaces with coarse or fine finish.[11] Furthermore, the author of this in vitro study explained that the different results found in literature can be attributed to various factors including time of repair, use of a mercury-rich interface, the effects of roughening the fracture segments, type of alloy used, and the use of adhesive resins.

RESIN COMPOSITE AND VOLUMETRIC SHINKAGE:

The successful use of high-molecule-weight epoxy and methacrylate-derivatives that incorporate inorganic fillers led to biggest advancement in clinical performance of polymer-based restorative materials in the late 1950's and early 1960's, and introduction of a large hydrophobic dimethacrylate, known as Bis-GMA, greatly facilitated the commercial use and

development of resin composite.[12] However, one of major disadvantage of resin based composites is volumetric shrinkage. All composite materials undergo volumetric shrinkage upon setting and it results undesired development of contraction stresses as high as 13MPa between the composite and the tooth structure.[13]

Cavity configuration factor (C-factor) is properties of material and it refers to the ratio of bounded to unbounded tooth surface. As the C-factor of a bonded restoration increase, the contraction stress of the restoration increases as well.[14] The polymerization contraction stress has potential to increase gap formation at the cavo-surface margin, and it leads to the contamination, post-op sensitivity, increased risk of recurrent cares, pulpitis, and marginal staining.[15] In order to reduce the net effect of polymerization shrinkage, the typical packable resin composite is added to the cavity in 2 mm increment between curing and additional placements. This incremental layering technique can reduce the effect of polymerization shrinkage, but it can cause the restorative procedure time consuming and voids may be incorporated between the layers.[16]

Recently a new class of resin composites materials, the bulk-fill resin composite, have been introduced and gaining the popularity to its clinical effectiveness. Sure-Fill SDR is a stress decreasing resin technology based flowable resin and it can be placed with maximum 4mm increment (bulk fill) in large and deep Class 1 and Class 2 cavities.[17] Van Dijken and Lindberg demonstrated in their research that the 4mm bulk fill technique with the flowable resin composite SDR was highly clinically effective as it was comparable with the 2mm resin composite layering technique during 3-year randomized controlled study. This recently developed resin composites with low stress and flowable behavior allows simpler restorative filling process as well as ideal choice of material for potential Amalgam repair for my research.

COMPOSITE BONDING:

An important factor which affects the quality of amalgam repair is bonding between the repair material and the existing restoration.[18] Current resin-based adhesive can be divided into two major categories based on the number of clinical steps and their interaction with the tooth surface: "etch & rinse" and "self-etch".[19,20] Etch & rinse adhesive systems use phosphoric acid-etching of enamel and dentin before bonding, which can be beneficial, since the demineralized and uninfiltrated dentin area becomes the weak point of bond due to the hydrolytic degration of collagen.[11] Self-etch adhesive system have become popular in the last decade since its advantage includes reduced application time and technique-related sensitivity as it is believed to prevent hydrolytic degration of bonded structure.[11,21]

Clearfil SE Bonding is a self-etch adhesive and it has been shown good clinical outcome with long-term retention rate: the 13-year retention rate of Clearfil SE Bond the clinical trial was high (96%) and only one restoration was lost on each group, comparable to 13-year retention rate of 94% for Optibond FL in a clinical trial with similar study design.[22]

MATERIALS AND METHODS

Microleakage will be evaluated after prepared samples were stored in dye solution for one hour. Its testing procedure, methodology, evaluation criteria is closely following similar amalgam repair study performed by Ozer and others[23] as well as previous AEGD residents.

Materials:

Amalgam: Tytin FC (Regular Set) 800mg – Modified spherical amalgam with the firm packing of admix or dispersed phase materials. (Lot # 16-4236)

Sure-Fill SDR flow + (Bulk-Fill flowable composite): Universal Shade, curing time is 20 sec upto 4mm depth. (Lot #160505)

TPH Spectra (resin composite): A1 Shade, LV – low viscosity packable resin composite. (Lot #150411)

Clearfill SE Bond 2 (bonding agent): Universal Self-Etch bonding adhesive. (Lot # 000001)

NeoBurr Carbide FG245: Amalgam/Composite restoration prep carbide burs. Head diameter is 0.8mm and Head length is 2.7mm. (Lot #C160303)

Methylene Blue Dye: Methylene blue chloride, 1% Aqueous Solution. (Lot #AD-16006-1)

Kerr OptiMix: Programmable Computerized Mixing System - Amalgamator (SN#15026458)

Acteon Satelec Mini LED Curing Lights: Tri-mode LED Curing light with maximum power output of 1250 mW/cm^2 (Serial #303677-073)

Methodology:

Specimen Preparation

25 extracted human maxillary and mandibular molars were used for this research project.

All extracted teeth(samples) used in this research are stored less than 4 month in Thymol Solution. Initially all samples were grinded off with dental model trimmer grinder to remove cusps and make the occlusal surface flat (Figure 1.) Then, Class 1 preparation was created one side of tooth using carbide 245 burs with head length 2.7mm head length. A new bur was used for every two cavity preparations (both for amalgam and composite). Each cavity has approximately 2.7mm(W)X2.7mm(L)X2.7mm(H) dimension; The first cavity was filled with Tytin FC (Regular Set) amalgam (Figure 2) using programmable amalgamator (OptiMix) and its manufacture's recommended mixing time.

One day later, the second cavity was prepared in exactly identical dimension (2.7mX2.7mmX2.7mm) right next to the amalgam restoration (Figure 3). The samples randomly divided to two groups: 13 samples for as testing group and 12 samples for control group. The second cavities were filled to simulate a "clinical repair" using two composite materials: packable resin composite(TPH) as a control group and Bulk-fill composite(SDR) as test group (Figure 4). The resin composite materials and bonding agents were used manufacture's instruction. Clearfill SE Bond 2 Self-Etch bonding adhesive were used with selective etching technique. TPH resin composite were filled in two steps – two layering techniques (each layer is approximately 1.2 to 1.4 mm depth), and Bulk-fill SDR was filled in one single step in bulk and cured.

Testing and Data (photo image) Collection

All samples were stored in the distilled water at 25 degree Celsius for 60 hours, and then they were covered with two layers of nail varnish (Maybelline) applied within 1 mm of restoration margins. The samples were mounted on acrylic jigs and they were placed in methylene blue dye solution (1:10 solution of 1% methylene blue chloride) for one hour at room

temperature (25-degree C). The samples were removed from the dye and rinsed under tap water for one minute.

The teeth were sectioned with isomet saw in a mesio-distal direction (Figure 2). Each section of two halves were pictured using a Canon D60 digital camera with 100mm macro lens, and digital images were stored for data analysis and leakage scoring. Each sample has two digital images from each half, but only one side with most visible and highest leakage was considered for further data(score) analysis by two independent evaluators (SM and AY) for dye penetrations assessments.

Data Analysis:

Data(images) was evaluated and analyzed using scoring system by two evaluators (Table 1). In case of disagreements, the differences in score values were discussed among two evaluators and final value was obtained on consensus.

Table 1. Microleakage scoring system for experiment

Score System:	Value
No Leakage	0
< ½ way to the pulpal floor	1
Upto the Pulpal Floor	2
1/2 of Pulpal Floor	3
More than 1/2 of Pulpal Floor	4

RESULTS

A Mann-Whitney test was performed to evaluate the median micro-leakage of Amalgam composite interface and tooth composite interface using Bulk-fill resin composite and TPH repairing materials. Data analysis was accomplished using SPSS v20 (IBM, Armonk, NY,

USA). An institutional review board waiver was obtained in accordance with the use of publicly available de-identified data.

Overall leakage scores for the tooth composite interface (Mdn = 0) were not significantly different than the amalgam composite interface (Mdn = 0). Among the tooth composite interface, the leakage score distributions did not significantly differ between TPH and Bulk-fill resin (Mann–Whitney $U = 66.00$, $P = 0.36$). In contrast, among the amalgam composite interface, a Mann-Whitney test indicated that the leakage score in the Bulk-fill group (Mdn = 0) differed from the TPH group (Mdn = 3), $U = 36.50$, $P = 0.02$.

Table 2. Overall leakage Scores for Bulk-fill and Packable Composite

Material	**Amalgam/Composite interface** Median(Mdn)	**Tooth/Composite interface** Median(Mdn)
Bulk-fill Composite	0	0
Packable Composite(Control)	3	0

DISCUSSION

All sample preparation contains both enamel and dentin interface to restoration margin. The transition from enamel to dentin structure was identified at axial wall of the restoration on all samples. One of sample (#2) was omitted from data analysis due to pre-existing caries was detected during sample preparation and testing. The image of sectioned photo in Figure 4 reveals that caries was infiltrated from buccal pit and extended closely to pulpal tissue. This caries exposure led to weakening of tooth structure and marginal leakage around the restoration which was depicted well with methylene blue dye infiltration in Figure 4. Even without the missing one sample, number of samples were sufficient for data analysis, and other studies on dye penetration in Class II restoration showed that a sample size of twelve would discriminate in the range a dye penetration of 1.0 mm at enamel margin and 2.2mm a dentinal margin.[24]

The evaluation of marginal seal or leakage with the penetration of different dye (i.e. methylene blue, silver nitrate, radioactive marker) represents the most common method because of its simplicity according to Heintz.[24] He also argued that macro-tensile and micro-tensile bond strength test correlated better with clinical retention of cervical restoration, and microleakage test with dye penetration does not correlate well with clinical parameters such as post-op sensitivity, retention, or marginal sealing.[24] However, the same author also stated that the dye penetration tests are the only method to evaluate materials variants in the laboratory, especially for effectiveness of pit & fissure sealants, and to gain some safety before clinical trials begin.

Other marginal leakage study involved in quantitative analysis with light microscope or scanning electron microscope to measure the length of gap or leakage under investigation. Majority of leakage study using dye penetration methods involves in either qualitative or semi-quantitative as these evaluation makes the test not very reliable or discriminative.[25] Author

pointed out that the evaluation can be carried out in the plane which the sample is sectioned, which can be misleading because the dye infiltration does not occur uniformly at the interface.[25] One of recent leakage study in dental restoration, by same author, involves micro-computed tomography (micro-CT) to allows 3D reconstruction of the dental restoration and its surround tissues and to quantify the volume of leakage using sliver nitrate infiltration and image segmentation.[25]

Based on the result of the study, Bulk-fil flowable composite is preferred for amalgam repairs over the packable resin composite. The marginal adaptation is one of most the important, and same time it is one of the weakest area in a restoration.[26] Since Bulk fill SDR is behavior like flowable composite, it may have better marginal adaptation, resulting less leakage score compared to package resin composite. Other clinical recommendations for amalgam repairs published in journal of Dental Materials published in 2013 by Hickel are followings: 1) Use of resin-based composite to repair amalgam 2) Silica coating, followed by the use of a silane, a bonding agent and a resin-based composite 3) Etch and rinse adhesives rather than self-etch adhesive 4) Glass-ionomer cements (comparable with those to enamel and significantly higher than those to dentin) or Resin modified glass ionomer cements. [3]

CONCLUSION

In vitro study demonstrates that Bulk-fill resin composite has less leakage score at repaired amalgam to resin composite interface compared to traditional packable resin composite. Repair with flow-able type resin composite is conservative and evidence-based approach to treat defective amalgam restoration as long as the affective margins are relatively shallow and located in non-stress bearing area. Evaluating different methods and techniques for amalgam repairs are necessary in

order to choose optimal treatment for patient's clinical circumstances and needs. Bulk-fill resin is viable material of choice for repairing the amalgam restoration, however, further bond strength tests, durability test, and clinical trials are needed to verify its long-term success and performance of material.

Table 3: Microleakage Scoring for Bulk-fill composite vs. TPH composite

Sample #	Tooth/Composite Interface	Amalgam/Composite Interface	Materials
1	0	0	Bulk-fill
6	0	0	Bulk-fill
7	0	3	Bulk-fill
8	1	0	Bulk-fill
9	0	2	Bulk-fill
10	0	0	Bulk-fill
11	0	0	Bulk-fill
12	0	2	Bulk-fill
13	0	0	Bulk-fill
15	0	0	Bulk-fill
17	0	0	Bulk-fill
20	0	0	Bulk-fill
24	0	0	Bulk-fill
2	N/A	N/A	TPH
3	0	0	TPH
4	0	2	TPH
5	0	0	TPH
14	0	3	TPH
16	0	3	TPH
18	0	3	TPH
19	0	4	TPH
21	0	3	TPH
22	0	0	TPH
23	0	3	TPH
25	0	0	TPH

Score System:	Value
No Leakage	0
< ½ way to the pulpal floor	1
Upto the Pulpal Floor	2
1/2 of Pulpal Floor	3
More than 1/2 of Pulpal Floor	4

Note: Sample #2 was omitted from evaluation/scoring due to pre-existing caries.

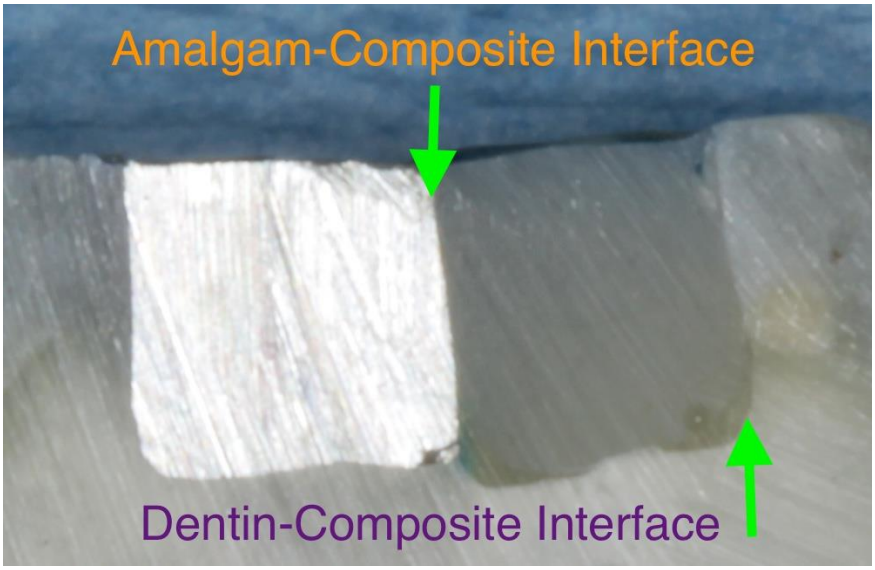


Figure 1: Amalgam-Composite and Dentin-Composite interface after samples were sectioned with isomet saw

Figure 2: Sample is being cut with Isomet saw

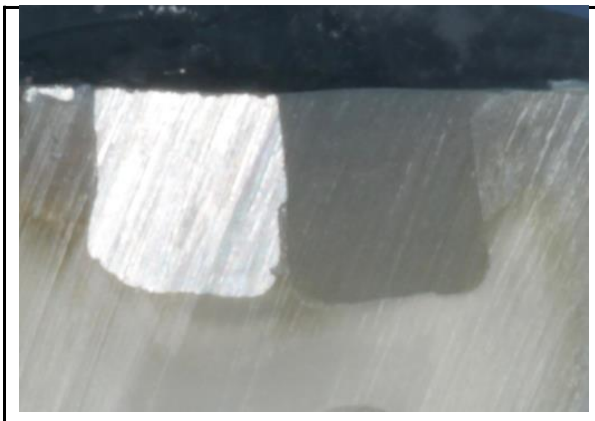


Figure 3. Sample #1 Cross Section Cut

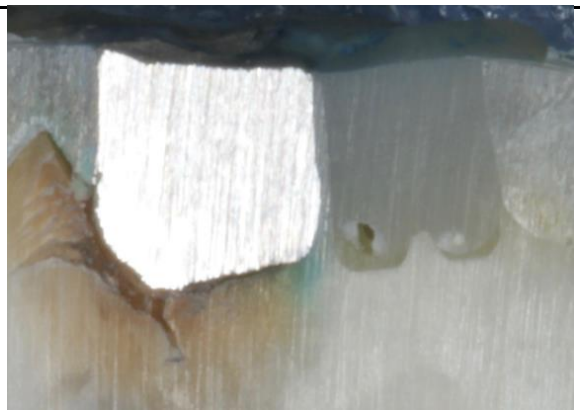


Figure 4. Sample #2 Cross Section Cut

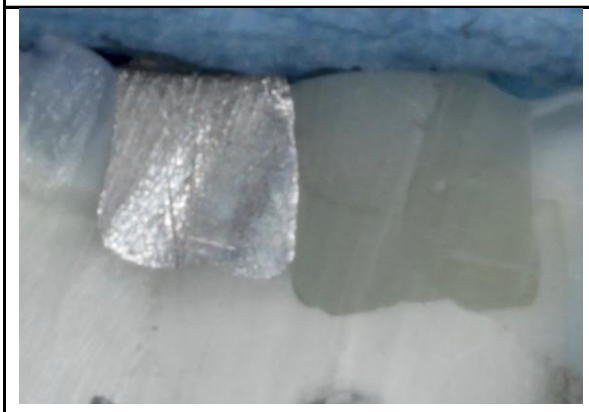


Figure 5. Sample #3 Cross Section Cut

Figure 6. Sample #4 Cross Section Cut

Figure 7. Sample #5 Cross Section Cut

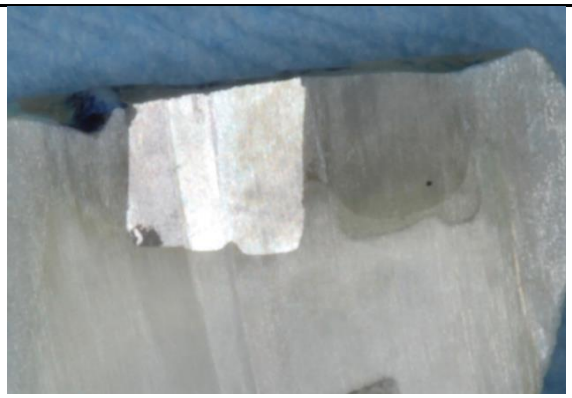


Figure 8. Sample #6 Cross Section Cut

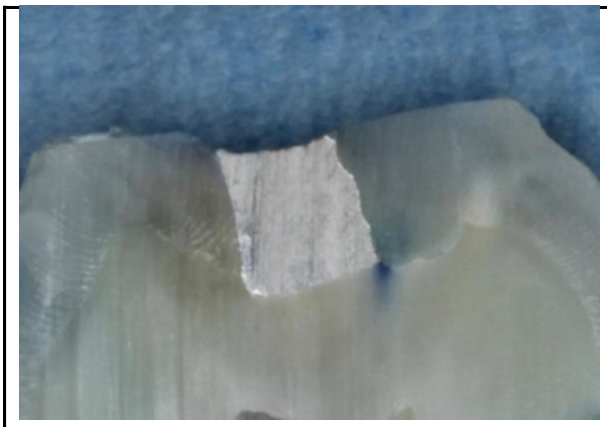


Figure 3. Sample #7 Cross Section Cut

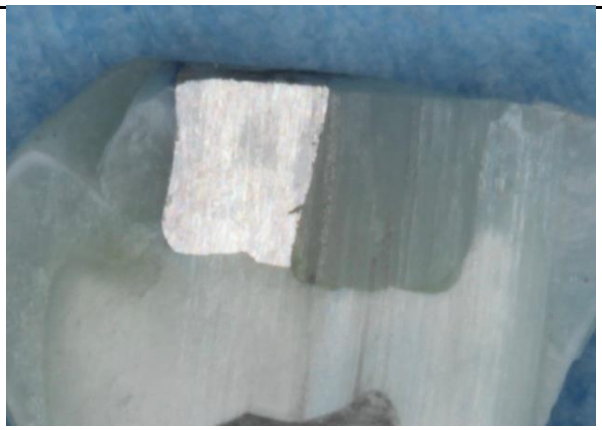


Figure 3. Sample #8 Cross Section Cut

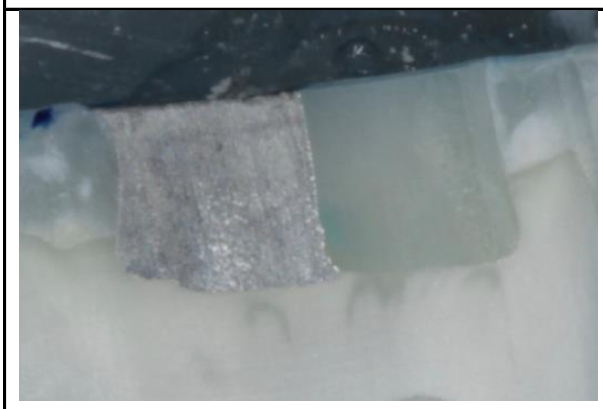


Figure 3. Sample #9 Cross Section Cut

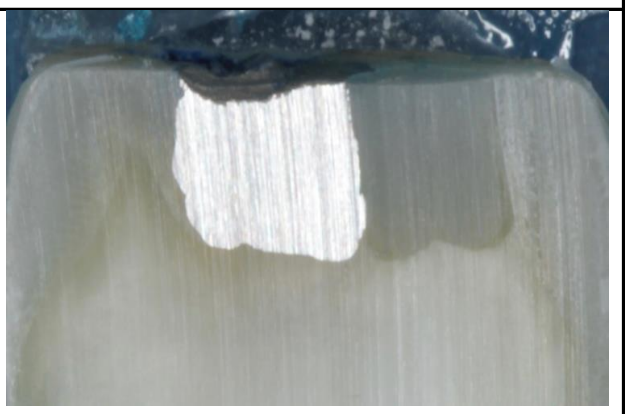


Figure 3. Sample #10 Cross Section Cut

Figure 3. Sample #11 Cross Section Cut

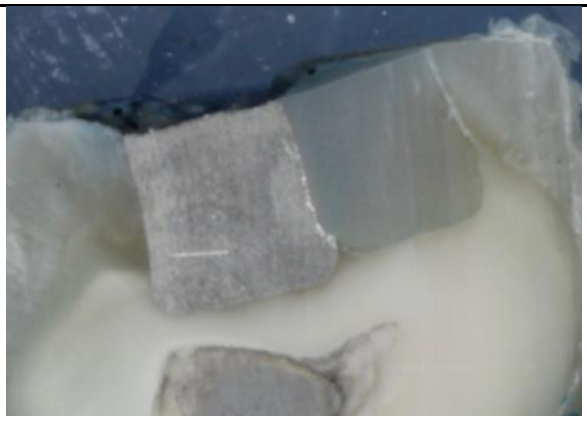
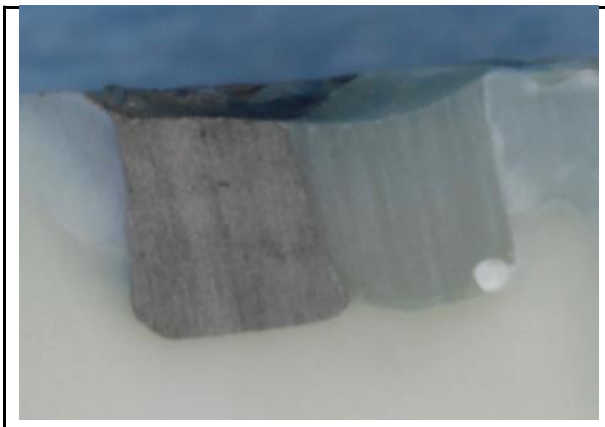


Figure 3. Sample #12 Cross Section Cut



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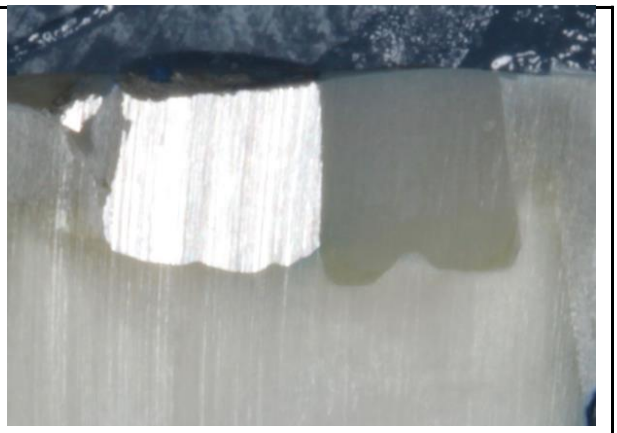

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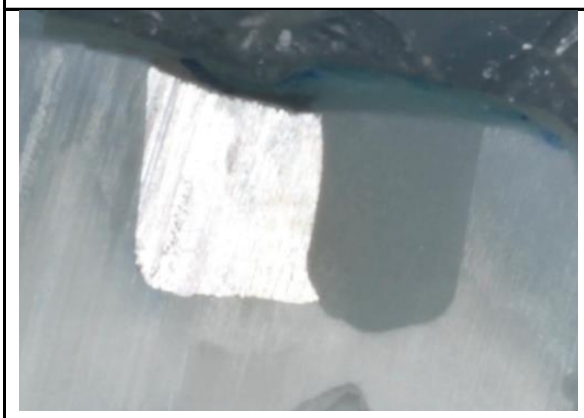

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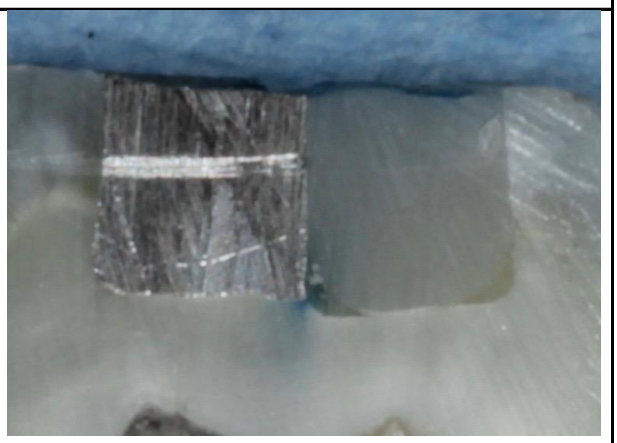
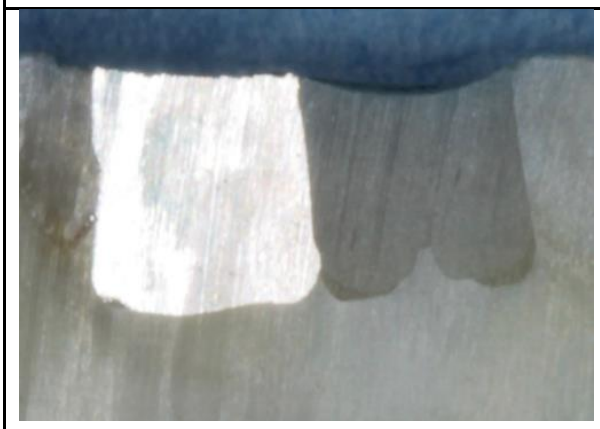


Figure 3. Sample #16 Cross Section Cut



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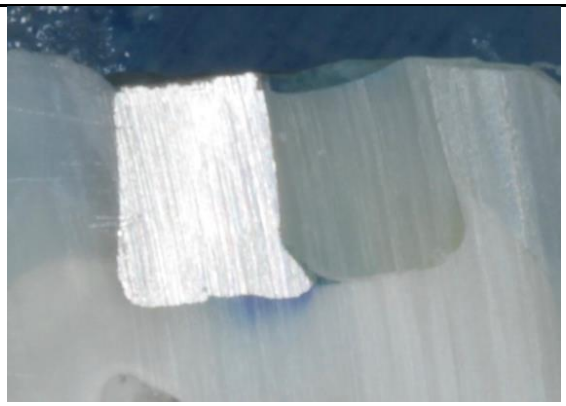

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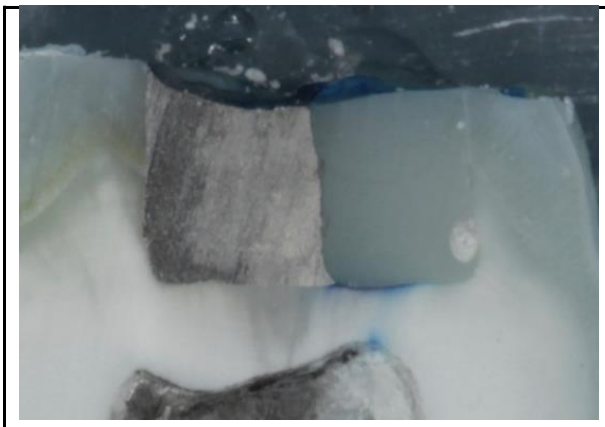

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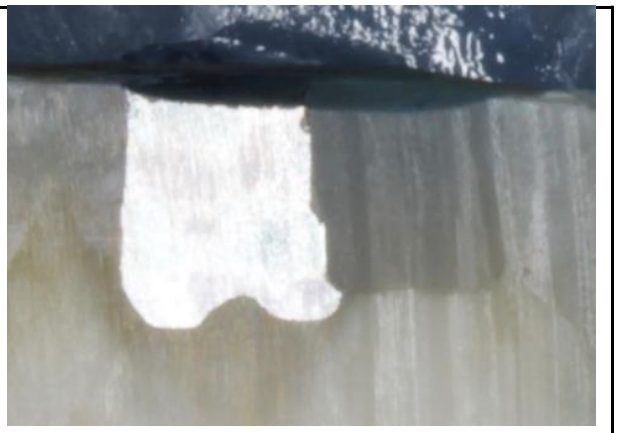

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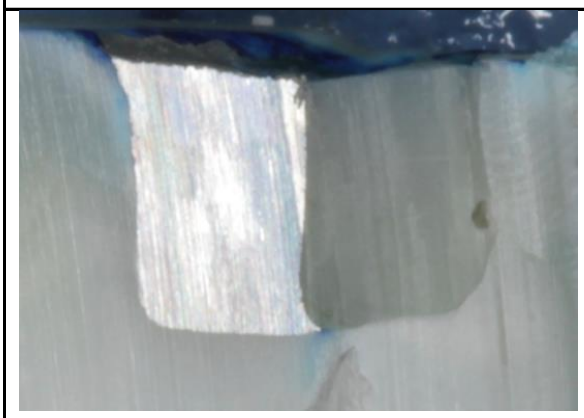

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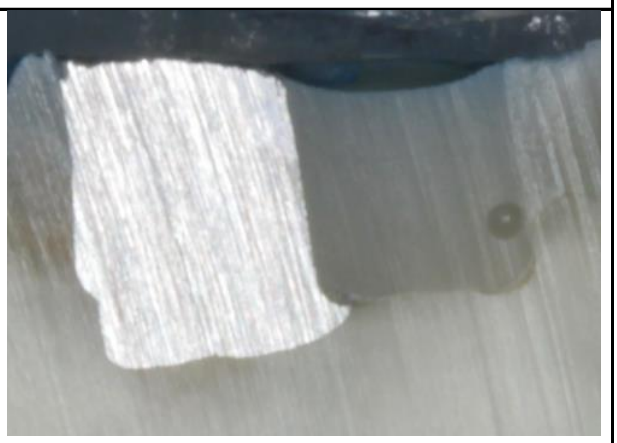
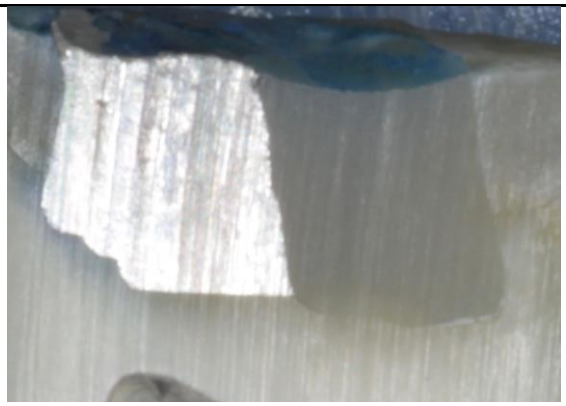


Figure 3. Sample #22 Cross Section Cut

Figure 3. Sample #23 Cross Section Cut



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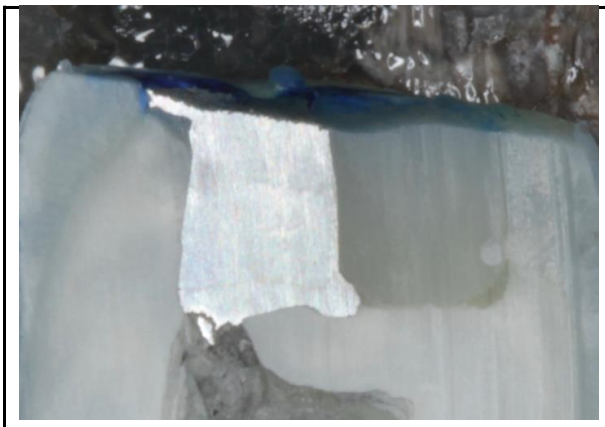

Figure 3. Sample #25 Cross Section Cut

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