Dental Filling Modification to Improve Mechanical Loading Test Report

Test Type			
☒	Design Qualification	☐	Design Validation
☐	Design Verification	☐	Process Validation

Project Title	Dentistry Elevated
Project Leader	Joseph Foley
Origination Date	[YYYY-MM-DD]

1. INTRODUCTION

1.1 The objective of the Dentistry Elevated Modified Filling testing was to determine whether the modified fillings allow for more shear loading than a basic filling. While dental fillings perform very well in compression, the performance in shear is lacking for these fillings. By adding fiber optic glass pins, the filling should, theoretically, be able to take more load in shear than a basic filling.

2. TEST SUMMARY

2.1 The testing was done according to protocol 1500-vp-001 section 5. Samples were prepared by Dentistry Elevated, and consisted of a human wisdom tooth, resin base, and either a basic filling or modified filling. By placing the tooth sideways against a retaining vice and pressing down on the extruded filling with a pressing vice, the allowable shear load can be determined for the filling's bond. The basic fillings consist of a UV curable composite, while the modified fillings consist of the same composite, but also include the addition of two fiber optic glass rods which are placed inside the filling. All samples, both basic and modified, had the filling placed entirely in the dentin of the tooth.

3. DEVIATIONS FROM PROTOCOL

3.1 The test setup verification only required the use of three samples, the values for these samples have been recorded in the appendix. The original tables to record values during testing only had columns for sample, force, and comments, however, in test discussion it was determined that displacement may also be useful data. Displacement in mm has been added as a column to tables 1 and 2.

4. CONCLUSIONS

4.1 Acceptance criteria

1) Record Average and standard deviation of the test samples and perform a 2-sample T-test.
   a) Based on a P-value of .003 the test shows a statistically significant improvement in the failure load of the pinned samples compared to the baseline samples.
2) The modified filling samples must have a higher shear load than the baseline filling samples.
   a) On average, the load is 27 lbf. higher on the pinned samples compared to the non-pinned samples, with comparable standard deviations of the data sets.

4.2 Results

Table 1. Basic filling results

Sample #	Failure Load (lbf)	Displacement at Failure (mm)	Comments
1	39.8	0.86	very quite, clean break
2	58	1.12	clean pop
3	53	0.89	clean pop, good sample
4	22.8	0.65	Filling came off with no noise and barely any force, tooth has a hole/cavity by the bond
5	70.8	1.59	explosive pop
6	45.6	1.16	clean pop
7	73.4	1.77	explosive pop
8	12.6	0.3	filling came right off
9	49.8	1.05	explosive pop
10	52	1.08	clean pop, good sample
11	45.6	1.19	clean pop, good sample

Table 2. Modified filling results

Sample #	Failure Load (lbf)	Displacement at Failure (mm)	Comments
1	80.6	1.37	good sample, crisp pop
2	65.6	1.27	small crack prior to breaking, quiet pop
3	63.6	1.5	filling came completely off, pins sheared
4	59.8	1.12	had two distinctively separate breaks, pins sheared, hole in the tooth right next to the pins
5	94	1.42	good sample, hard pop, pin shear, and enamel chipped off
6	64.4	1.04	filling barely separated
7	122.4	1.6	one pin sheared, one pulled out of tooth
8	71.2	2.64	tooth was rotating in resin before separation
9	65.6	1.08	pin shear, good sample
10	48.8	1.35	bit of filling chipped off around 10 lbf
11	90.4	1.08	solid pop, good sample

Table 3. Statistical analysis

Group	Average (lbf)	Standard Deviation (lbf)	T Test – P Value
Basic	47.58	17.25	----
Modified	75.13	19.60	----
Difference	27.55	2.35	.0033

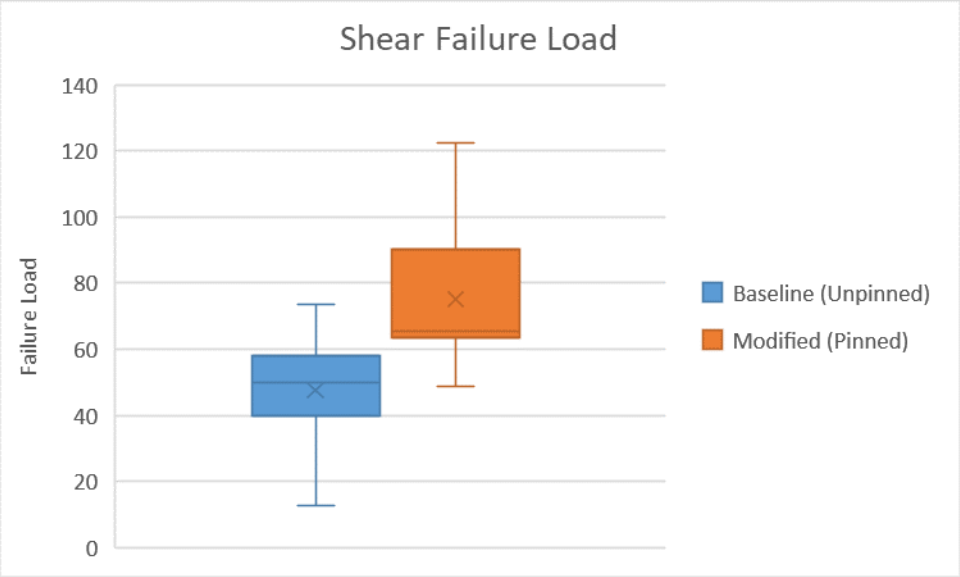

Figure 1. Failure Load Comparison

Figure 2. Failure mode 1 (slight separation)

Figure 3. Failure mode 2 (clean breakage)

Figure 4. Group 1 sample 4, evident holes on bond line

Figure 5. Pins shearing in group 2 samples when there was a clean break

4.3 Analysis of Results.

1) From table 3, the average failure load of the modified fillings is significantly greater than that of the base fillings. The standard deviation is slightly higher for the modified fillings, but not significantly different. It is important to note that the T-test has a value lower than .05 which means the modified fillings demonstrate statistical significance in comparison to the base fillings. This means the modified fillings are an overall improvement when compared to the base fillings.

4.4 Discussion of Results.

1) For the base fillings, all failures were mode 2. However, for the modified fillings, samples 1, 2, 6, 10, and 11 demonstrated mode 1 failure. In mode 1 failure, at least one glass pin did not shear, and the filling simply separated from the tooth. All other samples in the modified fillings demonstrated failure seen in figure 4 where the pins would shear upon separation.

2) In testing of the base fillings there are two outliers in the data, one is 12.6 lbf and the other is 22.8 lbf. These values have not been omitted from the data. However, if they were, the group one average and standard deviation go to 54.22 lbf and 10.75 lbf, respectively. This would also move the T-test value to .014 which is still less than .05 and shows statistical significance.

5. APPENDICIES

5.1 Refer to 1500-vp-001-02 for all test set-up, and diagrams. Refer to 1500-PN-002_01 for test memo.

5.2

Table 4. Test setup verification

Sample #	Failure Load (lbf)	Displacement at Failure (mm)	Comments
1	74	1.57	very short filling, almost entirely on enamel
2	81.4	1.61	clean break off, pins pulled out of tooth
3	59.6	1.87	dead silent break, pins sheared

Revision History

Revision	Description of Updates	Date
01	Initial Release	1/11/2024

Approvals

Name Title	Signature	Date
Joey Foley Originator - Title		
James Robbins Engineering Manager		
Jeremy Ellis, DDS Owner, Dentistry Elevated		