EVALUATION OF MOUTH GUARD FOR AMALGAM LEACHING

Submitted by

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March 6, 2014

I. INTRODUCTION

A clear plastic mouth guard with gray discoloration on its back molars was submitted to the Georgia Tech Research Institute's Materials Analysis Center (GTRI MAC) for evaluation of possible dental amalgam leaching.

II. SAMPLE IDENTIFICATION

GTRI Lab Number 012414-001: Mouth Guard

III. EXPERIMENTAL SUMMARY

Upon receipt, the mouth guard was photo-documented and entered into a chain of custody with an individual GTRI lab number. The mouth guard was then visually/optically inspected to determine the location of the possible contamination. The rearmost molars on each side of the guard were found to be the most heavily discolored gray. The mouth guard was then cut into sections for SEM/EDS analysis to determine the elemental composition of the areas of interest. The discolored left and right molars were tested for possible amalgam contamination, and an incisor (with no visible discoloration) was tested as a baseline for the mouth guard material. Both darkened molar areas showed possible traces of mercury (Hg), with the highest concentration occurring in the darkest areas. The presence of several other elements can be attributed to saliva and the natural oral environment.

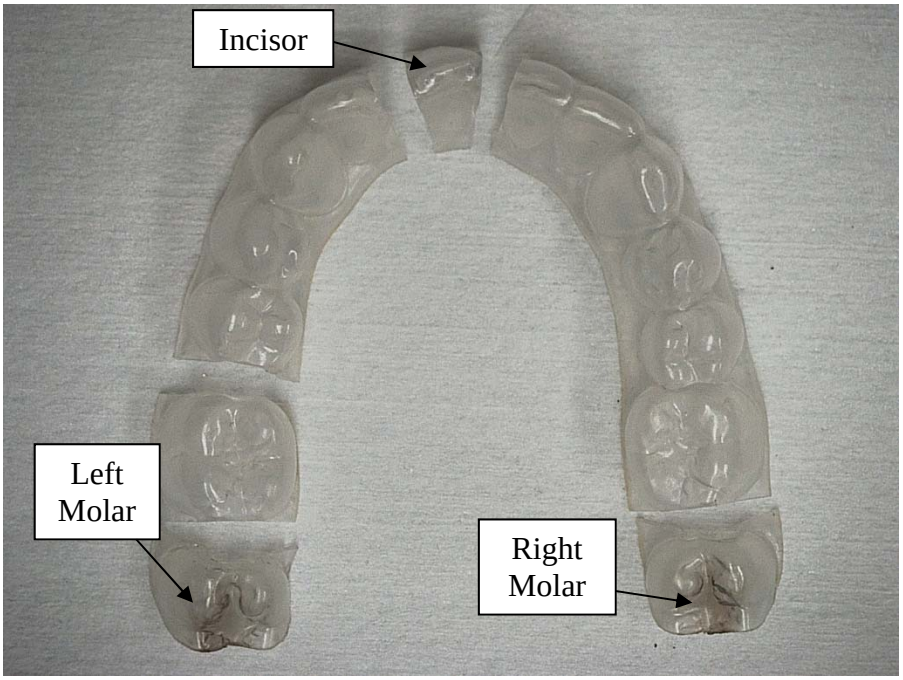

Figure 1: Sectioned mouth guard with labeled test portions

IV. TESTING PROCEDURES AND INSTRUMENTATION

An Hitachi SU8030 high resolution scanning electron microscope (SEM) integrated with a Thermo Noran System 7 energy dispersive X-ray spectroscopy (EDS) system was used to collect the elemental data. Minimum elemental sensitivity is 1000 parts per million (i.e. 0.10 El. Wt. %).

A sterile scalpel blade was used to cut the mouth guard as shown in Figure 1. Cutting was required for to produce sample sizes suitable for SEM/EDS testing. After each cut, the blade was replaced with a new one to avoid cross-contamination. Unpowdered nitrile gloves were used at all times when handling portions of the mouth guard. All portions of the mouth guard have been retained and will be returned upon request.

All testing followed good laboratory practices and ASTM standard testing procedures.

V. TEST RESULTS: IMAGES AND SEM/EDS ASSAY ANALYSES

Figures 2 and 3 are log-in images of the mouth guard in the case. Figures 4-6 are images of the sectioned test pieces from the left and right molars and the incisor. Each image is labeled with specific test areas, which correspond to the labels in Tables 1-6. Tables 1, 3, and 5 present the averaged EDS elemental data for each test piece, and Tables 2, 4, and 6 present the elements of each test piece by concentration.

VI. DISCUSSION

The composition of the incisor devoid of any darkened discoloration was used as a comparison against the gray areas of both rear molars of the mouth guard (Figure 1). The most common plastic used to mold dental mouth guards is acrylic resin. The composition of acrylic resin contains carbon (C), oxygen (O), and hydrogen (H). Note: The element hydrogen is not detected by SEM/EDS. The chemical assay of the incisor contains only C, O and some aluminum. The source of the aluminum is not straight forward but is possible an inorganic filler molded with the acrylic resin.

The dark gray discolored back molars of the mouth guard likewise contain C, O, and Al along with many other elements shown in Tables 1 to 4. All of elements observed in the darkened molar regions are typical of oral fluids and from teeth EXCEPT the heavy metal mercury (Hg). The concentration of Hg in both molar areas averages 400 parts per million or 0.40 El.Wt.%. The source of the mercury is likely from mercury amalgams that resided underneath the back molar areas of the mouth piece. It is apparent that mercury was leached from the amalgams via galvanic or electrolytic corrosion processes, and such leaching has been documented in Kenneth Anusavice's Phillips' Science of Dental Materials, 10th ed. Sections on Corrosion and Dental Amalgams Structure and Properties. If the amalgams are available, testing can be performed to determine the cause(s) of the mercury leaching or corrosion.

Figure 2: Log-in image of sample, case closed, as received

Figure 3: Log-in image of sample, case open, as received

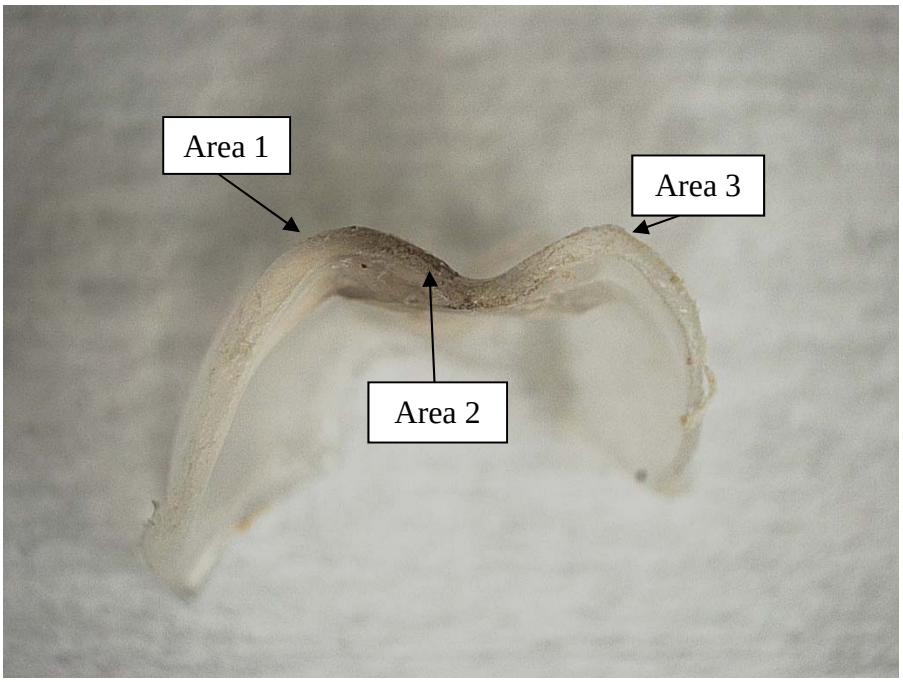

Figure 4: Left molar, rear exposed edge with labeled test areas

Table 1. Elemental composition of left molar test areas, elemental weight %

SEM/EDS Elemental Composition, Weight %											
Left Molar	**C**	**N**	**O**	**Na**	**Al**	**Si**	**P**	**S**	**Cl**	**Ca**	**Hg**
Area 1	51.7	14.9	29.7	1.8	0.2	0.3	0.2	0.4	0.3	0.1	0.4
Area 2	40.6	11.4	44.4	1.3	0.4	0.2	0.5	0.4	0.1	0.1	0.6
Area 3	40.9	11.7	43.9	1.8	1.1	0.1	0.1	0.1	0.1	0.0	0.1
Average	**44.4**	**12.7**	**39.3**	**1.6**	**0.6**	**0.2**	**0.3**	**0.3**	**0.2**	**0.1**	**0.4**
Standard Dev.	6.3	1.9	8.3	0.3	0.5	0.1	0.2	0.2	0.1	0.1	0.3

Table 2. Elements by concentration of left molar

Left Molar		
Major	**Minor**	**Low**
C, N, O	Na	Al, Si, P, S, Cl, Ca, Hg

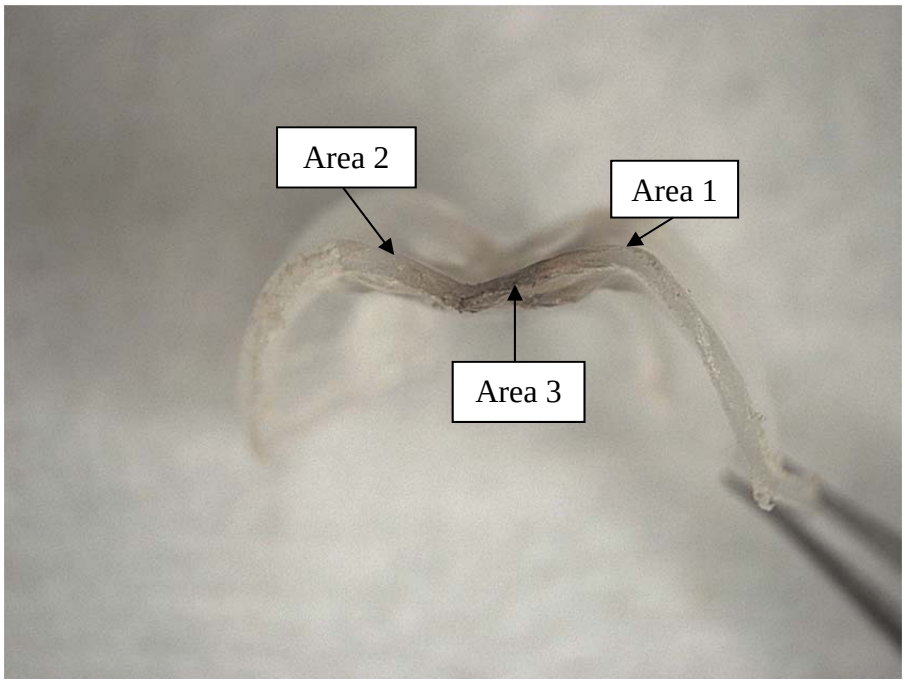

Figure 5: Right molar, rear exposed edge with labeled test areas

Table 3. Elemental composition of right molar test areas, elemental weight %

SEM/EDS Elemental Composition, Weight %													
Right Molar	**C**	**N**	**O**	**Na**	**Mg**	**Al**	**Si**	**P**	**S**	**Cl**	**K**	**Ca**	**Hg**
Area 1	45.4	15.1	36.7	1.3	0.1	0.3	0.2	0.2	0.2	0.2	0.0	0.1	0.1
Area 2	42.4	13.1	37.5	4.6	0.0	0.3	0.1	0.3	0.4	0.9	0.2	0.0	0.2
Area 3	39.5	11.3	42.9	3.2	0.1	0.4	0.1	0.4	0.4	0.5	0.1	0.2	0.9
Average	**42.4**	**13.2**	**39.0**	**3.0**	**0.1**	**0.3**	**0.1**	**0.3**	**0.3**	**0.5**	**0.1**	**0.1**	**0.4**
Standard Dev.	3.0	1.9	3.4	1.7	0.1	0.1	0.1	0.1	0.1	0.4	0.1	0.1	0.4

Table 4. Elements by concentration of right molar

Right Molar		
Major	**Minor**	**Low**
C, N, O	Na	Mg, Al, Si, P, S, Cl, K, Ca, Hg

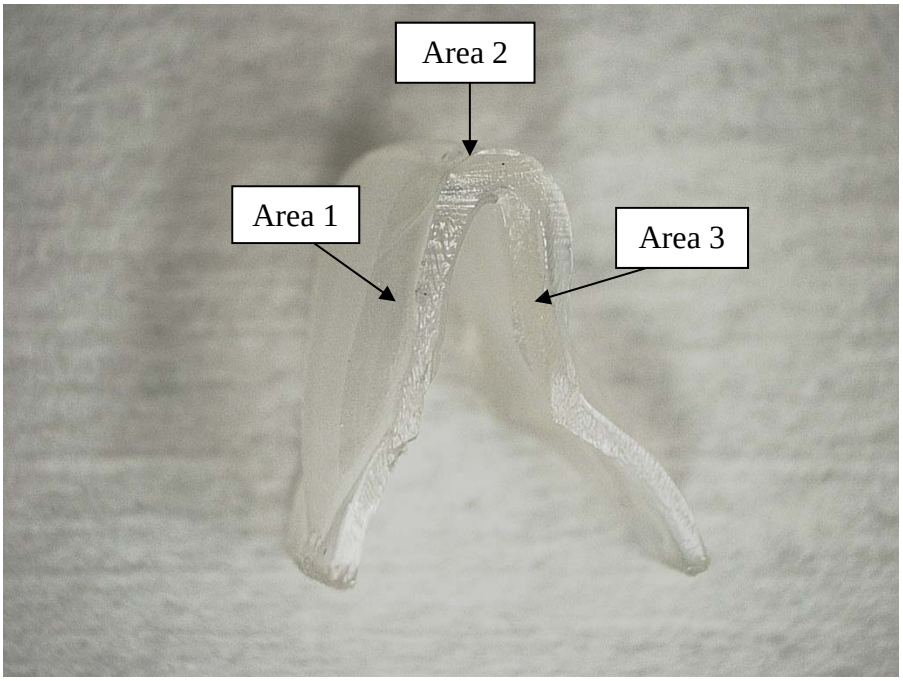

Figure 6: Incisor, with labeled test areas

Table 5. Elemental composition of incisor test areas, elemental weight %

SEM/EDS Elemental Composition, Weight %			
Incisor	**C**	**O**	**Al**
Area 1	91.8	4.8	3.3
Area 2	89.7	8.2	0.9
Area 3	84.8	12.1	3.1
Average	**88.8**	**8.4**	**2.4**
Standard Dev.	3.6	3.7	1.3

Table 6. Elements by concentration of incisor

Incisor		
Major	**Minor**	**Low**
C	O, Al	N/A

In conclusion, mercury amalgams have been used for 183 years due to their good properties of strength, plasticity, ease of workability, and affordability. However, the use of mercury in the oral environment has raised questions of human safety since its inception in dentistry. Currently, several countries are phasing out the use of Hg-containing dental amalgam because of environmental concerns as well as alleged side effects that may be sustained by the patients who receive amalgam restorations (Anusavice, page 402). In particular are biocompatibility side effects, hypersensitivity reactions, and toxicity. For a more detailed discussion about the physiological and neurological effects of mercury on humans, I recommend consultation with a toxicologist or epidemiologist.

Thank you for allowing me to assist you with your discolored mouth guard assay study. Please feel free to contact me with questions.

Respectfully submitted,

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