ELECTRIC TEETH:
CHEMICAL REACTIONS IN THE MOUTH
AND THE PHENOMENON OF ORAL GALVANISM
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Introduction

When Jaro Pleva, PhD, published a study entitled "Corrosion and Mercury Release from Dental Amalgam" in 1989, he aptly noted that in order to accurately report on mercury releases from dental amalgam, "…specialist competence in the following fields is required: materials science, corrosion/electrochemistry, toxicology, medicine/diagnostics, physical biology, analytical chemistry."[1]

Not ironically, a number of years prior to that, Pleva, dentist Olle Redhe, DDS, and Mats Hanson, PhD and IAOMT Fellow, had communicated about oral galvanism with G. Wrangle'n, a professor of Technical Electrochemistry and Corrosion Science. At one point, Wrangle'n wrote to Redhe and Hanson, "The history of science shows that new, revolutionary theories often are met by ignorance and even persecution by established science. This reflects a serious defect in human intellect which someone ought to write a book about."[2]

The comment by Wrangle'n is especially poignant because the science behind oral galvanism is an essential aspect of recognizing the hazards of dental mercury. In fact, Hanson suggested that it would be fitting for researchers to simply replace the term *oral galvanism* with the term *mercury poisoning*.[3]

The existence of oral galvanism can be easily explained; however, the factors that play into oral galvanism and its ensuing consequences make it a much more complex topic. Unfortunately, without this more detailed understanding of oral galvanism, the entire concept of dental mercury poisoning is missing a crucial part of its equation.

The cornerstones of oral galvanism: Demystifying the phenomenon of electric teeth

Suggesting that the mouth could be a battery and that teeth can be electric probably sounds blatantly bizarre to just about anyone who has not studied oral galvanism. Yet, the fact that such a situation can actually occur is quite elementary.

First, defining the technological term *oral galvanism* assists greatly in conveying information about this dental phenomenon. *Galvanism* is defined as "a direct current of electricity especially when produced by chemical action."[4] Thus, *oral galvanism* simply means electric currents produced by chemical action in the mouth.

Next, one must have a fundamental understanding of electricity in order to realize that circumstances in the human mouth could generate such currents. In the event one does not recall

the lesson on the basics of electricity from their days in school, the MIT School of Engineering's description of how a battery works provides a brief review:

> There are three main components of a battery: two terminals made of different chemicals (typically metals), the anode and the cathode; and the electrolyte, which separates these terminals. The electrolyte is a chemical medium that allows the flow of electrical charge between the cathode and anode. When a device is connected to a battery—a light bulb or an electric circuit—chemical reactions occur on the electrodes that create a flow of electrical energy to the device.
>
> More specifically: during a discharge of electricity, the chemical on the anode releases electrons to the negative terminal and ions in the electrolyte through what's called an oxidation reaction. Meanwhile, at the positive terminal, the cathode accepts electrons, completing the circuit for the flow of electrons.[5]

Northwestern University also offers an explanation on battery operation. They specify that the battery consists of an anode (-), a cathode (+), and an electrolyte. Chemical reactions between these result in electrons congregating at the anode, creating an electrical disparity. The researchers note:

> You can think of this difference as an unstable build-up of the electrons. The electrons want to rearrange themselves to get rid of this difference. But they do this in a certain way. Electrons repel each other and try to go to a place with fewer electrons. In a battery, the only place to go is to the cathode. But, the electrolyte keeps the electrons from going straight from the anode to the cathode within the battery. When the circuit is closed (a wire connects the cathode and the anode) the electrons will be able to get to the cathode.[6]

At this point, one might still be wondering about how this highly charged situation could possibly occur in the mouth. Considering all of the available options for dental materials, the accessibility to metals to serve as the anode and cathode in the oral cavity is abundant. For example, research from 2012 by Zohdi, Emami, and Shahverdi entitled "Galvanic Corrosion Behavior of Dental Alloys" listed the metals that serve as the base of commonly used dental alloy types, including gold, palladium, silver, cobalt, nickel, titanium, iron, and of course, mercury.[7] The research also identifies additional elements used as ingredients in these alloys.

As another example, Pleva reported in his 1989 study, "Though the combination of gold and amalgam is the most frequent case of oral galvanic cell, galvanic corrosion can occur between many other metals used for dental restorations." Pleva goes on to give an example of a stainless steel screwpost that impacted dental amalgam.[8]

Obviously, a mouth with any amount of metallic dental work has all the metals needed to produce chemical reactions, but saliva also plays a role, serving as the electrolyte, especially due to the contents of saliva, which can contain varying levels of calcium, magnesium, potassium, and acid.[9] Zohdi et al. provide a simple explanation of the process: "In dentistry application, galvanic corrosion occurs when two or more dental prosthetic devices with dissimilar alloys

come into contact while subjected to oral liquids like salvia; the difference between the corrosion potentials results in a flow of electric current between them."[10]

A Swedish study from 1983 by Nordenström describes how other parts of the mouth can also play a role in oral galvanism:

> Thus, in oral galvanism the intraoral ionic conducting branch, formed over the saliva between two electron conductors, may combine with one or several parallel-coupled, biological conducting branches in surrounding tissues. These branches, for instance, may be represented by blood vessels and interstitial channels… A galvanic current through the circuit can now develop between metals of different electric potential even when these metals are separated by a distance.[11]

Finally, an interesting aspect to emphasize here is that oral galvanism is widely accepted but marginally understood. There is general consensus that oral galvanism exists, as dental textbooks have included reference of it for decades.[12] Therefore, most dental authorities acknowledge oral galvanism, and Health Canada has even stated that "new amalgam fillings should not be placed in contact with existing metal devices in the mouth, such as braces."[13] However, when it comes to fully taking heed of the consequences of oral galvanism, the evidence does not appear to have significantly altered dental practices.

Factors that influence chemical reactions in the mouth and the impact on patients

It is not surprising that the term *oral galvanism* is often used synonymously with the term *galvanic corrosion*. This is because a primary action of electrical currents in the mouth is to cause corrosion, similar to the rust that appears on batteries, cars, and other metallic objects. Indeed, it is typically accepted that electrical currents in the oral cavity result in more extreme corrosion of the dental materials and that this, in turn, can result in more metallic releases. Zohdi et al. explain: "The higher the corrosion rate of the alloy, the greater the metal ion release and the greater the risk of undesirable reactions in the mouth."[14]

This potential for increased metallic releases has certainly been confirmed in the case of amalgam fillings,[15] which are known to produce mercury vapor and particles,[16] as well as free mercury droplets,[17] during the corrosion process.

A gamut of factors can determine the rate of corrosion, and research has identified a number of situations that can increase corrosion, including the ones on this much abbreviated list:

- the combination of gold and amalgam[18] [19]
- the different surfaces of the restoration[20]
- the composition of saliva and dentin fluid[21]
- biting, wear and tear, increase in temperature, and acidic and salty food[22]
- "'injury reactions' at the interfaces between gingival or root canals and the restoration metals'"[23]
- periodontitis or chronic periodontitis[24]

Similarly, a wide-range of symptoms from oral galvanism have been reported in patients. Galvanic currents have been associated with sharp pains, and galvanic corrosion has been linked to metallic tastes in the mouth, allergy, and irritation.[25]

Additionally, oral lesions,[26] blackening of crevice surfaces,[27] amalgam tattoos,[28] and *all* of the symptoms related to mercury poisoning[29] have been linked to oral galvanism from amalgam fillings.

Furthermore, the release of mercury particulate, which can occur due to oral galvanism and amalgam fillings, can cause releases of mercury with the potential to result in mercury-resistant and antibiotic-resistant microflora.[30] Mercury particulate has also been suspected of being able to produce methylmercury in the mouth[31] [32] [33] [34] and in the gut.[35] [36] (Pregnant women and children are warned not to eat certain types of seafood due to methylmercury.)[37]

Conclusion

While oral galvanism has been studied for nearly a century, the number of dental alloys used since the 1980's has noticeably increased,[38] and more and more chemical combinations are occurring in the mouths of patients.

When it comes to oral galvanism, it is clear that established dental and medical practices have not yet embraced the science behind this phenomenon. In fact, as research continues to prove and examine human health risks caused by mixing different metals in the mouth, somehow the electric currents—and the denial over their intensity and consequences—continue to ensue.

At the same time, as biocompatibility is considered and utilized more often in dentistry, there is hope for the issue of oral galvanism to be resolved. The truth of this distinct possibility is evident in the recovery of some patients who have had dental materials harmful to their systems removed. While numerous studies have documented recovery of symptoms after safe amalgam removal, studies specifically about oral galvanism have likewise observed the improved health of some patients who had the incompatible, electricity-generating dental materials taken out of their mouths.[39] [40]

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