ELECTRICAL CURRENTS FROM DENTAL METALS AS AN ETIOLOGIC FACTOR IN ORAL CANCER

MELVIN C. REINHARD AND HAROLD A. SOLOMON

(From the State Institute for the Study of Malignant Diseases, Buffalo, N. Y., Burton T. Simpson, M.D., Director)

Electrical action from dental metals must be classified as a source of oral irritation, and should be included among the etiological factors considered in the production of precancerous and cancerous lesions of the buccal cavity. It can readily be conceived that if the presence of unlike metals in the mouth results in the formation of a battery, the minute currents thus generated, acting over a long period of time, may result in injury to the soft oral tissues, followed by subsequent tissue reaction. The fact that such a battery in the mouth may be a source of constant irritation, leading to definite injury to the soft tissues, has received the attention of a number of workers.

Ewing (1) mentions the possibility of soft tissue irritation from "electrical discharges from some dental plates," and points out the fact that such oral irritation, together with other factors, might cause malignancy. Lain (2, 3) states that, in addition to other lesions which he attributed to such action, "a few cases of leukoplakia, a precancerous lesion, have been recently reported." Fitzwilliams (4) of London, in his textbook, "The Tongue and Its Diseases," as quoted by Hollander, Permar and Schonfield (5, 6), says: "A leukoplakia may be caused by electric currents set up by different metals used for stopping teeth and in the formation of tooth plates." Hollander (5) working alone, and later with Permar and Schonfield (6), reported several oral lesions including leukoplakic areas which he ascribed to galvanism produced by metallic dental restorations.

A review of observations on this subject recently published by the authors (7) shows that as far back as 1876 Palmer (8) and Chase (9) independently reported on "galvanic action from metals used to restore lost tooth structure." Palmer stated: "Every tooth filled with metal is a miniature battery subject to the same fundamental law"—of electrical circuits. Chase announced his belief in the theory of Palmer, and proceeded to recount several experiments made by himself which convinced him of the truth of this theory.

In this connection it is of historical interest to note that some of our fundamental knowledge pertaining to electricity is founded on observations of work accomplished experimentally by placing dissimilar metals in the mouth. Sulzer (10), a contemporary of Galvani and Volta, working in the year 1767, observed that the application of two

1 Read before the American Association for Cancer Research, Toronto, March 28, 1934.
dissimilar metals within the mouth, one above and the other below the tongue, gave rise to the perception of a peculiar taste when the two free ends of the metals were brought into contact. This was evidence of electrical activity.

Among all the metals, including gold, silver, copper, mercury, etc., which are commonly used in dentistry for restoring lost tooth structure, there exist differences in electrical potential. It is from these differences that the so-called “electromotive series” is derived. The immersion of any two of these metals in an aqueous solution of an electrolyte constitutes a simple galvanic battery. When the metals are connected externally, by means of a conductor, electric current flows from one metal to another. Thus, in the mouth, with dissimilar or alloyed metallic restorations, a simple galvanic battery exists, since the metals are bathed in saliva, which is a solution of several electrolytes. In order to complete the analogy, the soft tissues of the mouth, being a good conductor, may be compared to the external circuit mentioned above.

More specifically in reference to the possibility of electrical action resulting in cancer, our observations have led us to the consideration of three important factors that appear to be involved in this phenomenon. They are: (1) the relationship of galvanometer measurements of dental metals in situ to accompanying pathologic changes; (2) local action; (3) polarization.

Considering the universal use of metals to replace lost tooth structure, and on the other hand the comparative rarity of pathologic changes which may be attributed to this cause, two questions may well be raised. Does electric current actually flow in all of these mouths? Is it possible to measure this current in order to establish a relation between it and the lesions present or the possibility of the development of such lesions?

Lain (2), in an endeavor to answer these questions, inserted a microammeter between separate fillings and obtained currents as high as 100 microamperes, which are relatively large currents capable of producing considerable damage. However, it is not correct to consider that the current so measured represents the actual flow of current normally present in the mouth. By normal current, in this case, is meant that current which might actually be flowing between the restorations. Further, the measured current is not necessarily even related to the normal current, although there is a possibility that it might be. In other words, the current through the meter can be a separate and distinct entity, existing without any normal current, and its presence is no proof whatsoever that a normal current exists.

On the other hand, if we consider that the meter circuit, when introduced into the mouth, may establish a circuit parallel to the normal flow through the soft tissues, a definite relation may exist between the two, and the meter readings would therefore bear a relationship to the injury produced by such a current.

* In order to confirm the possibility that this relation may exist
between tissue damage and measured current, we proceeded to obtain readings from approximately 100 people, including both patients and personnel of the Institute. The instrument used was a portable galvanometer. Contact between the meter and the metallic fillings was established by means of platinum needle points.

The results obtained have been published in part in a previous communication (11) and may be briefly summarized as follows:

1. Currents ranging as high as 80 microamperes were obtained in the mouths of all people having more than one metallic restoration, with the exception of those mouths in which 24-carat gold comprised the fillings. All other restorations, whether of amalgam or gold alloy, showed readings.

2. The value of the current dropped within five seconds to a steady minimum, approximately 10 per cent of the initial value, when the contactors were held in place for an appreciable length of time.

3. High, as well as low, values were obtained in those mouths which presented pathologic lesions and were in no manner or degree different from the values obtained where no untoward symptoms were present.

Thus our two questions may be answered by saying that the possibilities for electrical action were present, although we are as yet unable to offer any evidence that current is normally flowing, and secondly that there is no relationship between the values of the current measured by the galvanometer and the production of objective or subjective symptoms.

We are of the opinion that, while a galvanic cell may exist under such conditions as are present in the mouth, little or no current flows from one dental restoration to another; however, the nature of dental metals, when alloys are used, is such that some pathological changes may be ascribed to what we term "local action."

This phenomenon of "local action" (6) may be described as follows. An alloy, such as copper and gold, is merely a physical mixture of separate and distinct crystals of each constituent, and when these crystals coexist on the surface of a restoration there will be potential differences between them and the saliva, so that current will flow, thus constituting a minute galvanic cell. In this instance the external circuit is the restoration itself, and the internal circuit is completed through the saliva, and may or may not include the soft tissue.

As mentioned elsewhere (11), Bloodgood's (12) observation that "now and then a patch of leukoplakia can be produced by the irritation of a tooth, especially one with a metallic filling," is probably the result of such action.

The current generated by each of these microscopic cells is, of course, minute, but if one considers that there may be thousands of these cells on the surface of one restoration, and that they are working continuously, it can easily be imagined that considerable current is generated, and that accumulated end-products and effects of electrolysis may be sufficient to produce definite changes in the soft tissues.

That such "local action" might occur elsewhere is evidenced by
such occurrences as nickel dermatitis caused by wrist watches and spectacle frames. Lain (13) quotes a letter from an optical company relative to this subject, which states, "The trouble seems to be due largely to nickel that is found in white gold alloy. We believe the action is largely electrolytic; that is, an electrolytic battery action is produced when there are dissimilar metals and an acid or in some instances an alkaline fluid present and in contact with these dissimilar metals."

"When the perspiration, which is an electrolyte, acts upon the base, metal salts are formed and such action is more pronounced in the presence of heat. It is probably a salt of the nickel that causes the irritation of the skin where the metal comes in contact. The irritation seems to be analogous to a trouble that is present in the nickel-plating industry called commonly 'nickel itch.'"

To return to the consideration of such action in the mouth, the question may still be asked, why, in view of the electrical possibilities, are there not more cases cited where damage has been done? Is it possible that some mechanism of a protective nature acts to reduce the normal flow of current?

The mere fact that meter readings were obtained, the nature of which indicated that polarization was taking place immediately after the meter was introduced, can be considered proof that the mechanism for polarization was present in the mouth, and that polarization must have occurred immediately following insertion of the restoration. This would mean a reduction in the normal current at its inception. It is possible that the metallic taste noticeable immediately following insertion of a restoration, disappearing shortly afterward, is due to this phenomenon. The possibility of polarization opens an interesting line of speculation, for it appears that in some mouths a depolarizing agent may be present either continuously or intermittently, and would permit current to flow with resulting damage. Such may be the condition in those mouths in which lesions can be traced to electrical causes, and yet the galvanometer readings would bear no relation to the normal current flow.

Another piece of evidence which supports the theory that current is not normally flowing between restorations is the failure of the metals to wear away. In an ordinary battery, electrical energy is produced at the expense of one of the electrodes, which wears away. If currents of the order of those measured were normally flowing, there would be complete exhaustion of some of the restorations during the course of several years. Calculation shows that the amount of silver which would be transported by a fifty microampere current, would amount to 8 grams or 123 grains in five years. Clinical observation indicates

Polarization under the above conditions is due to the fact that the hydrogen formed as a result of the current flow does not all escape as a gas, but part of it is bound by one of the electrodes of the electrolytic cell. This forms a film on the surface which repels more ions of like charge from approaching the electrode, as well as acting as an insulator around that electrode. As a result, therefore, there is set up a counter or reverse electromotive force, or voltage, the effect of which is to reduce the flow of current.
that no erosion of this magnitude occurs, and this is considered as further evidence that currents of such magnitude are not normally flowing.

**Summary**

From observations made during the course of these measurements we concluded:

1. That a battery can exist in a mouth with unlike metallic restorations.
2. That the measurement of current by the meter is not proof that current is normally flowing from this battery through the soft tissue or saliva.
3. That the meter readings, taken as described, are not indicative of pathological changes, either present or potential.
4. That local action is to be regarded as of more consequence in the production of such lesions than the possibility of current flow from one restoration to another.
5. That the nature of the meter readings indicates that polarization may be considered as a protective mechanism, reducing or preventing a normal flow of electricity from the battery.

**Bibliography**