Measuring corrosion resistance of metallic alloys in the oral cavity

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INTRODUCTION: Metallic alloys are widely used materials in dentistry. Common dental metallic alloys are classified as high or reduced gold, Co-based, Ni-based, or Pd-Ag alloys, all characterized by a high degree of mechanical stability and elasticity. One of their main disadvantages, however, is the limited corrosion resistance, especially if more than one metal was incorporated in the patient's oral cavity. Therefore, many patients complain of taste irritations, metal taste, tongue burning, dry mouth, pain or irritation of the mucous membrane. These phenomena are often the result of metal ions released from the applied alloys during corrosion. Therefore, it is highly desirable to establish an objective tool for the *in vivo* measurement of corrosion resistance, as the recently introduced ec-pen.[1,2] The thin electrodes allow for electrochemical measurements directly at different locations within the oral cavity of the patient, which finally allow identifying the ion-releasing parts of the applied dental metals. The dentist together with the affected patient can search for more appropriate dental treatments that avoid the release of trouble-generating metal ions.

MATERIALS AND METHODS: The present study is based on the ec-pen that contains two electrodes as sensing heads shown in Fig. 1. Pushing the white-gray coloured tip towards the metal part of interest such as a crown (see Fig. 1), electrolyte is emitted to wet the surface and form electrical contact. This simple and fast procedure allows measuring the corrosion resistance within an area of about 2 mm^2. The present investigation comprises 26 patients, who received a crown or dentures and, subsequently, have complained of one or more of the symptoms mentioned above. The examined dental materials include alloys with high and reduced gold content as well as cobalt-based alloys exclusively from well-established suppliers as verified by means of energy-dispersive X-ray fluorescence analysis (EDX).

RESULTS: The ec-pen serves for impedance measurements to determine the corrosion potential. The visual inspection permits the discrimination between different levels of corrosion, which might be classified according to three levels: below detection limit, perceptible, and major corrosion. In more than 40% of the patients, corrosion was explicitly detected. In these cases, the measured impedance resistance was definitely well below 200 Ωcm^{-2}. Comparing the visual inspection with the ec-pen experiments, we have found a strong correlation. Impedance resistance values below 150 Ωcm^{-2} correspond to major corrosion, data between 150 Ωcm^{-2} and 250 Ωcm^{-2} can be associated with a perceptible level of corrosion, and an impedance resistance measurement with results above 250 Ωcm^{-2} does not exhibit any detectable corrosion on the metallic parts.

DISCUSSION & CONCLUSIONS: The results apply for the average values. Unfortunately, an individual experiment can lead to mis-interpretations. Therefore, several data are necessary to be acquired and faults cannot be entirely excluded. There exist numerous reasons that help to explain such problems. Firstly, the composition of saliva is patient-specific. Secondly, there is some minor variation in the chemical composition and microstructure of the dental alloys from the different suppliers. Thirdly, the handling of the ec-pen can become difficult for smaller metallic parts, which can be even covered by non-conducting ceramics or polymers. Finally, metals are frequently soldered, which can induce strong corrosion and can be identified performing EDX-measurements on fragments.

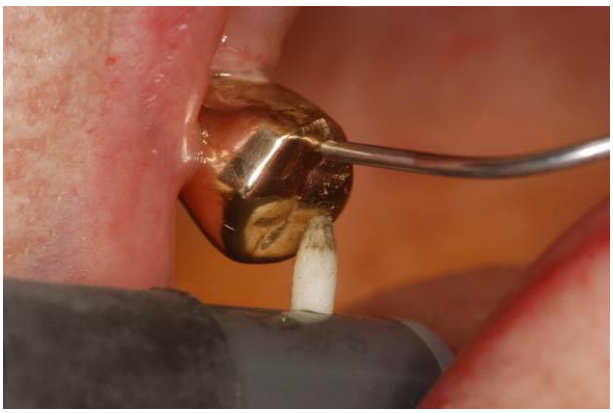

Fig. 1: Placement of the ec-pen electrodes on the crown.

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