Oxidative passivation of Ti for dental implants characterized by ec-pen

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INTRODUCTION: Titanium and its alloys are ubiquitous and indispensable for medical implants. Due to their protective native or man-made oxide layer they are usually inert to corrosion. Once the oxide layer is damaged the titanium itself is prone to corrosion. Corroding Ti implants may induce inflammatory reactions and negatively influence their functionality. Thus, it is a major concern to understand under which circumstances the oxide film is formed or dissolved. A method for such an analysis is an electrochemistry technique termed electrochemical impedance spectroscopy (EIS). Here, a special ESI setup is applied termed ec-pen. This setup is designed to measure corrosion *in vivo* as well as *ex vivo*, cp. Fig 1. It has been used in dentistry for more than ten years. In this presentation, the impact of milieu on changes of the passivation layer is addressed.

METHODS: Containing a working electrode (WE) and a reference electrode (RE) both immersed into the electrolyte (lactic acid 10.01 g/L – sodium chloride 5.8 g/L in distilled H_2O), enclosed in a reservoir, the ec-pen is a compact mean for electrochemical impedance studies. For measurements the pen's tip and a counter electrode (CE) are pressed against the Ti specimen, here Ti, grade 4. The samples were exposed to either ambient conditions, Ringer solution (B. Braun Melsungen AG, Germany) or artificial saliva (citric acid 47.6 M, Na citrate 47.6 M, NaCl 42,8 M, KSCN 2.6 M) for increasing time intervals before measurement. More detailed description of the experimental setup and functionality has been discussed previously [1-4].

RESULTS: A simple parallel RC circuit served as model for data analysis. The evaluated data show that the titanium oxidation is favoured in artificial saliva and Ringer solution compared to ambient atmosphere. The times obtained for half maximum values of the phase shift using the Michaelis-Menten fit are (54.5 ± 4.1) s for artificial saliva, (51.6 ± 3.3) s for Ringer solution and (280 ± 40) s for ambient atmosphere. The maximum values of the phase shift corresponds to (73.6 ± 1.6), (76.6 ± 1.0), and (68.3 ± 3.9) degrees, respectively, indicating significant variations in the thickness of passivation layers formed.

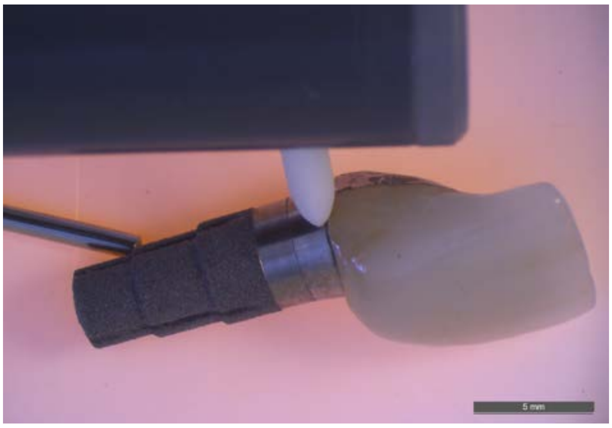

Fig. 1: The ex vivo measurement of a Ti implant with a ceramic crown attached using the ec-pen.

Table 1. The results depend on contact area and location [5].

	Impedance [Ω cm^2]	Phase [degree]
Tip 90° rel. to surface	354 ± 119	50 ± 6
Tip 45° rel. to surface	206 ± 65	48 ± 10

DISCUSSION & CONCLUSIONS: The results demonstrate that the oxidative passivation of Ti is massively influenced by the milieu present in oral cavity. The error bars are derived from the ec-pen's sensitivity taking into account the contact area issues and the dimensions of the meniscus of the electrolyte [5]. Thus, the obtained data have to be further evaluated. The limitation of the present study relates to restrictions on three milieus. Currently, a study with a broader scope to reveal the passivation mechanisms in detail is in planning stage.

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