Abstract

Studies on the decontamination methods for restoring biocompatibility of contaminated titanium surfaces

2018
Graduate School of Dentistry
Health Sciences University of Hokkaido

Yuki ICHIOKA

Two kinds of contamination to the implant surfaces which directly induced the reduction of biologic capability have been reported separately. The problems caused by the contaminations are known as “Biological Aging” and “Peri-implantitis”. Biological aging defines as an inevitable time-dependent degradation of osseointegration capability of titanium due to the absorbed organic impurities from the atmosphere during storage of implant. On the other hands, peri-implantitis defines as a plaque-associated pathological condition occurring in tissues around dental implants, characterized by inflammation in the peri-implant mucosa and subsequent progressive loss of supporting bone. The current thesis of studies has investigated, in-vitro, the surface decontamination methods for rejuvenating the biocompatibility of the contaminated titanium by the adsorption of atmospheric organic impurities in study I and for restoring the surface properties of the bacterial plaque contaminated titanium during surgical treatment of peri-implantitis in study II.

First of all, in study I, we evaluated the effects of chemical treatment using sodium hypochlorite (NaOCl) solution to the 2-weeks-old titanium surfaces. The aged titanium disks were immersed in 5% NaOCl solution for 24 hours. As a control, the disk immersed in distilled water for 24 hours was employed. XPS assay demonstrated that the organic impurities on the 2-week-old titanium were removed and the amount of hydroxyl group was increased after NaOCl treatment. The NaOCl treatment substantially converted the titanium surface to superhydrophilic ($\theta<5^\circ$), which resulted in increasing the number of attached cells and enhancing the cell spreading on the NaOCl treated surfaces. These results proposed that bio-functionalization of the titanium surface can be achieved by treatment with 5% NaOCl. The mechanism for desorption of strongly adsorbed organic molecules having polar groups such as amino and aldehyde groups from the titanium surface by ClO^- was discussed.

Secondly, in study II, we assessed the cytocompatibility of experimentally contaminated titanium disks, using a *Streptococcus gordonii* biofilm, after chemical treatment with aqua alkaline electrolyzed water (AAEW) as an adjunctive to air-abrasive debridement. The contaminated disks were treated with air-abrasion and immersion in either 0.9% NaCl (Air + NaCl), 0.05% AAEW (Air + AAEW), or 3%

H_2O_2 (Air + H_2O_2). The efficacy of biofilm removal, magnitude of initial cytocompatibility and surface chemical properties were determined. In all treatment groups, biofilms were observed to be completely removed. However, the data showed discrepancies for cell affinities among treatment groups, whereby: i) the number of cells attached to Air + AAEW was approximately 2-fold greater than that to Air + NaCl; and ii) cell spreading was enhanced on Air + AAEW compared with Air + NaCl or Air + H_2O_2. When evaluated by XPS, these discrepancies could be attributed to sufficient removal of organic-nitrogen deposits at the same magnitude as the pristine surface following Air + AAEW treatment. This study clarifies that chemical surface treatment with AAEW as an adjunctive to air-abrasive debridement may be beneficial in achieving re-osseointegration.

In summary, a better understanding of the relationship between surface chemical properties and cellular responses which demonstrated in the current thesis of *in-vitro* studies have a potential to assists in providing important information for achieving high-quality osseointegration and for treatment strategies of peri-implantitis, although further *in-vivo* and clinical study are needed.