The influence of abutment surface modification on the peri implant tissue


Park JB, Yang SM, Ko Y.

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Abstract

PURPOSE: The purpose of this study was to evaluate the surface characteristics of various implant abutment materials, such as titanium alloy (Ti6Al4V; Ma), machined cobalt-chrome-molybdenum alloy (CCM), titanium nitride coating on a titanium alloy disc (TiN), anodic oxidized titanium alloy disc (AO), composite resin coating on a titanium alloy disc (Res), and zirconia disc (Zr), using confocal microscopy and white light interferometry. Measurements from the 2 methods were evaluated to see if these methods would give equivalent results. The precision of measurements were evaluated by the coefficient of variation.

MATERIALS AND METHODS: Five discs each of Ma, CCM, TiN, AO, Res, and Zr were used. The surface roughness was evaluated by confocal laser microscopy and white light interferometry.

RESULTS: Confocal microscopy showed that the Res group showed significantly greater Ra, Rq, Rz, Sa, Sq, and Sz values compared with those of the Ma group (P < 0.05). The white light interferometry results showed that the Res group had significantly higher Ra, Rq, Rz, Rt, Sa, Sq, Sz, and Sdr values compared with the Ma group (P < 0.05). All the roughness parameters obtained from the 2 methods differed, and the Sa values of the Zr group from confocal microscopy were greater by 0.163 µm than those obtained by white light interferometry. Least difference was seen in the TiN group where the difference was 0.058 µm.

CONCLUSION: Roughness parameters of different abutment materials varied significantly. Precision of measurement differed according to the characteristics of the material used. White light interferometry could be recommended for measurement of TiN and AO. Confocal microscopy gave more precise measurements for Ma and CCM groups. The optical characteristics of the surface should be considered before choosing the examination method.
The influence of surface nanoroughness, texture and chemistry of TiZr implant abutment on oral biofilm accumulation.

Xing R¹, Lyngstadaas SP, Ellingsen JE, Text-Lamolle S, Haugen HJ.


Abstract

OBJECTIVES: The aim of the study was to examine surface nanoroughness, texture and chemistry of dental implant abutment and to investigate how these parameters influence oral biofilm formation in healthy subjects.

MATERIALS AND METHODS: Eight different nanorough TiZr surfaces were produced by polishing, machining, cathodic polarization and acid etching. Surface topography was examined using field emission scanning electron microscope and a blue light laser profilometer. Surface chemistry was analyzed by secondary ion mass spectrometry and X-ray photoelectron spectroscopy. Surface hydrophilicity was tested by measuring contact angle on the surfaces. A human in vivo study using a splint model was employed to evaluate oral biofilm accumulation on these surfaces.

RESULTS: Different surface textures (flat, grooved and irregular) were created with nanoroughness from 29 to 214 nm. Some test surfaces were incorporated with hydrogen by cathodic polarization and/or acid etching with HCl/H(2)SO(4). Nanoroughness (S(α)) positively correlated with microbial adhesion. Biofilm accumulation was less pronounced on flat and grooved than on irregular surfaces. No significant association between hydrogen content or hydrophilicity of the surface and biofilm accumulation was observed.

CONCLUSIONS: Nanoroughness (< 214 nm) and surface texture influence oral biofilm accumulation independent of surface chemistry and hydrophilicity. Surface hydrogen, which has previously been shown to promote fibroblast growth, does not affect biofilm formation.
Soft Tissue Integration of Hydroxyapatite-Coated Abutments for Bone Conduction Implants.

Larsson A¹, Andersson M, Wigren S, Pivodic A, Flynn M, Nannmark U.

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Abstract

PURPOSE: The protocol for bone conduction hearing implant surgery involves reduction of soft tissues around the abutment to minimize the risk of skin-related complications. The present investigation was undertaken to demonstrate that hydroxyapatite-coated abutments provide improved soft tissue integration compared with conventional (pure titanium) abutments and are suitable for use without surgical removal of subepidermal soft tissues.

MATERIALS AND METHODS: Forty-eight implants for bone conduction with two different types of abutments (test and control) were inserted in the skull parietal part of eight sheep. Test abutments had a hydroxyapatite-coated surface and a concave shape. Conventional titanium abutments were used as controls. A follow-up time of 4 weeks was used. Histomorphometric analyses of test and control samples were analyzed, and morphometric results were compared using mixed model analysis.

RESULTS: Histological assessment showed healthy soft tissues around the abutments with limited or no signs of inflammation. Hydroxyapatite-coated abutments showed intimate dermal adherence, while less close contact was noted for control abutments. Statistically significant differences in mean pocket depth (0.4 vs 1.6 mm, p = .0013) and epidermal downgrowth (0.6 vs 2.0 mm, p = .0003) between test and control abutments were recorded.

CONCLUSION: The study confirms that hydroxyapatite-coated abutments resulted in a significant reduction in pocket depth and improved soft tissue integration compared with conventional titanium abutments, possibly by providing tight adherence at the interface. Statistically significant reduced pocket depth formation and epidermal downgrowth were recorded.
Differential response of human gingival fibroblasts to titanium- and titanium-zirconium-modified surfaces.

Gómez-Florit M, Ramis JM, Xing R, Taxt-Lamolle S, Haugen HJ, Lyngstadaaas SP, Monjo M.


Abstract

BACKGROUND AND OBJECTIVE: Gingival fibroblasts are responsible for the constant adaptation, wound healing and regeneration of gingival connective tissue. New titanium-zirconium (TiZr) abutment surfaces have been designed to improve soft tissue integration and reduce implant failure compared with titanium (Ti). The aim of the present study was first to characterize a primary human gingival fibroblast (HGF) model and secondly to evaluate their differential response to Ti and TiZr polished (P), machined (M) and machined + acid-etched (modMA) surfaces, respectively.

MATERIAL AND METHODS: HGF were cultured on tissue culture plastic or on the different Ti and TiZr surfaces. Cell morphology was evaluated through confocal and scanning electron microscopy. A wound healing assay was performed to evaluate the capacity of HGF to close a scratch. The expression of genes was evaluated by real-time RT-PCR, addressing: (i) extracellular matrix organization and turnover; (ii) inflammation; (iii) cell adhesion and structure; and (iv) wound healing. Finally, cells on Ti/TiZr surfaces were immunostained with anti-ITGB3 antibodies to analyze integrin β3 production. Matrix metalloproteinase-1 (MMP1) and inhibitor of metallopeptidases-1 (TIMP1) production were analyzed by enzyme-linked immunosorbent assays.

RESULTS: On tissue culture plastic, HGF showed no differences between donors on cell proliferation and on the ability for wound closure; α-smooth muscle actin was overexpressed on scratched monolayers. The differentiation profile showed increased production of extracellular matrix components. Ti and TiZr showed similar biocompatibility with HGF. TiZr increased integrin-β3 mRNA and protein levels, compared with Ti. Cells on TiZr surfaces showed higher MMP1 protein than Ti surfaces, although similar TIMP1 protein production. In this in vitro experiment, P and M surfaces from both Ti and TiZr showed better HGF growth than modMA.

CONCLUSION: Taking into account the better mechanical properties and bioactivity of TiZr compared with Ti, the results of the present study show that TiZr is a potential clinical candidate for soft tissue integration and implant success.
Surface modification and its effect on attachment, spreading, and proliferation of human gingival fibroblasts.

Zhang F, Huang Y, Li X, Zhao S.


Abstract

PURPOSE: The purpose of this study was to exploit potential methods of surface modification for improving the seal between the neck portion of a dental implant and the surrounding soft tissue.

MATERIALS AND METHODS: Titanium surfaces were modified by machining (SM-Ti group); machining and acid etching (AE-Ti group); or machining, acid etching, and depositing 4.5 collagen/hyaluronic acid (col/HA) polyelectrolyte bilayers (CHC-Ti group). These were analyzed using scanning electron microscopy, scanning force microscopy, x-ray photoelectron spectroscopy, contact angle measurement, and quartz crystal microbalance measurement. The degradation behavior of the col/HA multilayer coating was measured. Next, human gingival fibroblasts (HGFs) were cultured on the different surfaces, and cell morphology and spreading were observed using fluorescence microscopy and a shape factor measurement. Cell proliferation was examined by fluorometric quantification of the amount of cellular DNA. Matrix formation of HGFs was determined via enzyme-linked immunosorbent assay. Gene expression was analyzed via reverse transcriptase polymerase chain reaction.

RESULTS: Similar surface topology for these three groups was observable on a microscopic scale, and morphologic differences were apparent on the nanoscale. Both acid etching and col/HA deposition improved the hydrophilicity of the titanium surface, in contrast to machining alone. Each col/HA bilayer was about 5 nm thick. The col/HA coating degraded in about a week. Attachment and spreading of HGFs was better on the CHC-Ti surface than on the SM-Ti or AE-Ti surfaces. Moreover, the proliferation and differentiation of HGFs were greatly stimulated when cultured on CHC-Ti.

CONCLUSION: In contrast to two control surfaces (one machined, one machined and acid-etched), col/HA treatment of Ti improved the attachment, spreading, proliferation, and differentiation of HGF.
Enhanced attachment, proliferation, and differentiation of human gingival fibroblasts on titanium surface modified with biomolecules.

Jin C, Ren LF, Ding HZ, Shi GS, Lin HS, Zhang F.


Abstract

Surface modification of dental implants with biomolecules is of particularly interest recently. To mimic the structure and function of native extracellular matrix (ECM), a derivative of hyaluronic acid (HA), HA-GRGDSP, was synthesized. Arg-Gly-Asp (RGD)-containing collagen (Col)/HA multilayer polyelectrolyte films (MPFs) coating was fabricated on titanium (Ti) through alternate deposition of Col and HA-GRGDSP with 4.5 assembly cycles; moreover, bioactive molecule, basic fibroblast growth factor (bFGF), was also incorporated into such coating. This coating was then carefully characterized using scanning electronic microscope (SEM) and scanning force microscopy (SFM); bFGF release from the coating was also evaluated. (Col + bFGF)/HA-RGD coating was successfully deposited on Ti surface, and about 300 pg of bFGF could be slowly released from this coating for a week. This coating significantly promoted the initial cell attachment of human gingival fibroblasts (HGFs) compared with other groups (p < 0.05), and HGFs adhered and spread better on this coating than other groups (p < 0.05). Regarding cell proliferation and differentiation of HGFs, they were greatly stimulated when cultured on this coating (p < 0.05). These results indicated that surface modification of Ti using biomolecules might improve the sealing between the neck section of a dental implant and the soft tissue.
Differential Behavior of Fibroblasts and Epithelial Cells on Structured Implant Abutment Materials: A Comparison of Materials and Surface Topographies.


Abstract

PURPOSE: The aim of this study was to compare the proliferation and attachment behavior of fibroblasts and epithelial cells on differently structured abutment materials.

MATERIALS AND METHODS: Three different surface topographies were prepared on zirconia and titanium alloy specimens and defined as follows: machined (as delivered without further surface modification), smooth (polished), and rough (sandblasted). Energy-dispersive X-ray spectroscopy, topographical analysis, and water contact angle measurements were used to analyze the surface properties. Fibroblasts (HGF1) and epithelial cells (HNEpC) grown on the specimens were investigated 24 hours and 72 hours after seeding and counted using fluorescence imaging. To investigate adhesion, the abundance and arrangement of the focal adhesion protein vinculin were evaluated by immunocytochemistry.

RESULTS: Similar surface topographies were created on both materials. Fibroblasts exhibited significant higher proliferation rates on comparable surface topographies of zirconia compared with the titanium alloy. The proliferation of fibroblasts and epithelial cells was optimal on different substrate/topography combinations. Cell spreading was generally higher on polished and machined surfaces than on sandblasted surfaces. Rough surfaces provided favorable properties in terms of cellular adhesion of fibroblasts but not of epithelial cells.

CONCLUSIONS: Our data support complex soft tissue cell-substrate interactions: the fibroblast and epithelial cell response is influenced by both the material and surface topography.
Human gingival fibroblast (HGF-1) attachment and proliferation on several abutment materials with various colors.

Kim YS, Ko Y, Kye SB, Yang SM.


Abstract

PURPOSE: An implant abutment should be soft tissue-compatible and resistant to plaque accumulation, and it is preferable for an implant abutment to have color harmony with the surrounding tissues. This study aimed to compare the in vitro fibroblast cell attachment and proliferation on several abutment materials of different colors.

MATERIALS AND METHODS: A total of 240 specimens in 6 experimental groups were used: titanium alloy (SM [smooth machined]; gray), cobalt-chrome-molybdenum alloy (CCM; gray), titanium nitride-coated titanium (TiN; yellow), anodic-oxidized titanium (AO; dark pink), composite resin-coated titanium (R; white), and zirconia (Zr; white). The culture plate surface was employed as a control (C). The surface roughness (Sa), developed interfacial area ratio (Sdr), and water contact angle (WCA) were measured. The human gingival fibroblast (HGF-1) attachment and proliferation at the third and seventh days were observed.

RESULTS: Sa values of all experimental groups were < 0.5 µm. Sdr values were between 5% and 8%, except for the Zr group (0.06%). WCA of all groups was greater than 40 degrees. More HGF-1 cells attached on the surfaces of the SM, TiN, and Zr groups than the C group, and the least number of cells were observed on the CCM group (P < .001). On the third day of proliferation, the C group showed significantly greater proliferation than all experimental groups (P < .001). On the seventh day of proliferation, the TiN, AO, Zr, and C groups exhibited twice the number of cells compared to the rest of the groups (P < .001).

CONCLUSION: Within the limitations of this study, zirconia abutments would be the best choice in the anterior region. Titanium nitride-coated titanium alloy abutments or anodic-oxidized titanium alloy abutments might also be good choices in areas of esthetic challenge or under high occlusal loads.
Assessment of human gingival fibroblast interaction with dental implant abutment materials.

Rutkunas V, Bukelskiene V, Sabaliauskas V, Balciunas E, Malinauska M, Baltriuikiene D.


Abstract

The biocompatibility of dental implant abutment materials depends on numerous factors including the nature of the material, its chemical composition, roughness, texture, hydrophilicity and surface charge. The aim of the present study was to compare the viability and adhesion strength of human gingival fibroblasts (HGFs) grown on several dental materials used in implant prosthodontics. Surfaces of the tested materials were assessed using an optical imaging profiler. For material toxicity and cellular adhesion evaluation, primary human gingival fibroblast cells were used. To evaluate the strength of cellular adhesion, gingival fibroblasts were cultured on the tested materials and subjected to lateral shear forces by applying 300 and 500 rpm shaking intensities. Focal adhesion kinase (FAK) expression and phosphorylation in cells grown on the specimens were registered by cell-based ELISA. There was a tendency of fibroblast adhesion strength to decrease in the following order: sandblasted titanium, polished titanium, sandblasted zirconium oxide, polished zirconium oxide, gold-alloy, chrome-cobalt alloy. Higher levels of total as well as phospho-FAK protein were registered in HGFs grown on roughened titanium. Material type and surface processing technique have an impact on gingival fibroblast interaction with dental implant abutment materials.
Focal adhesion linker proteins expression of fibroblast related to adhesion in response to different transmucosal abutment surfaces.

Moon YH¹, Yoon MK, Moon JS, Kang JH, Kim SH, Yang HS, Kim MS.


Abstract

PURPOSE: To evaluate adherence of human gingival fibroblasts (HGFs) to transmucosal abutment of dental implant with different surface conditions with time and to investigate the roles of focal adhesion linker proteins (FALPs) involved in HGFs adhesion to abutment surfaces.

MATERIALS AND METHODS: Morphologies of cultured HGFs on titanium and ceramic discs with different surface were observed by scanning electron microscopy. Biocompatibility and focal adhesion were evaluated by ultrasonic wave application and cell viability assay. FALPs expression levels were assessed by RT-PCR and western blot.

RESULTS: There seemed to be little difference in biocompatibility and adhesion strength of HGFs depending on the surface conditions and materials. In all experimental groups, the number of cells remaining on the disc surface after ultrasonic wave application increased more than 2 times at 3 days after seeding compared to 1-day cultured cells and this continued until 7 days of culture. FALPs expression levels, especially of vinculin and paxillin, also increased in 5-day cultured cells compared to 1-day cultured fibroblasts on the disc surface.

CONCLUSION: These results might suggest that the strength of adhesion of fibroblasts to transmucosal abutment surfaces increases with time and it seemed to be related to expressions of FALPs.
Surface modification of zirconia with polydopamine to enhance fibroblast response and decrease bacterial activity in vitro: A potential technique for soft tissue engineering applications.

Liu M¹, Zhou J², Yang Y², Zheng M², Yang J³, Tan J⁴

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Abstract

The quality of soft-tissue integration plays an important role in the short- and long-term success of dental implants. The aim of the present study was to provide a surface modification approach for zirconia implant abutment materials and to evaluate its influence on fibroblast behavior and oral bacteria adhesion, which are the two main factors influencing the quality of peri-implant soft-tissue seal. In this study, polydopamine (PDA)-coated zirconia was prepared and the surface characteristics were evaluated using scanning electron microscopy, atomic force microscopy, a contact-angle-measuring device, X-ray photoelectron spectroscopy, and Raman spectroscopy. The responses of human gingival fibroblasts (HGFs) to PDA-coated zirconia; i.e., adhesion, proliferation, morphology, protein synthesis, and gene expression, were analyzed. Additionally, the adhesion of Streptococcus gordonii and Streptococcus mutans to zirconia after PDA coating was assessed by scanning electron microscopy and live/dead staining. The material surface analyses suggested the successful coating of PDA onto the zirconia surface. The PDA coating significantly increased cell adhesion and proliferation compared with pristine zirconia. HGFs exhibited a high degree of spreading and secreted a high level of collagen type I on PDA-modified disks. Upregulation of integrin α5, β1, β3 and fibronectin was noted in HGFs cultured on PDA-coated zirconia. The number of adherent bacteria decreased significantly on zirconia after PDA coating. In summary, our result suggest that PDA is able to modify the surface of zirconia, influence HGFs' behavior and reduce bacterial adhesion. Therefore, this surface modification approach holds great potential for improving soft-tissue integration around zirconia abutments in clinical application.