

JOÃO VÍTOR GOULART

**Efeito de cicatrizadores revestidos com Estrôncio sobre
parâmetros clínicos peri-implantares. Estudo clínico
controlado e randomizado em modelo de bocadividida.**

Effect of strontium-coated healing abutments on peri- implant
clinical parameters. Controlled randomized split-mouth clinical
trial

Dissertação apresentada à Faculdade de
Odontologia da Universidade Federal de
Uberlândia, para obtenção do Título de Mestre
em Clínica Odontológica, Área de Implantodontia
e Prótese sobre implante.

UBERLÂNDIA, 2023

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Iniciando os trabalhos o(a) presidente da mesa, Dr(a). Guilherme José Pimentel Lopes de Oliveira, apresentou a Comissão Examinadora e o candidato(a), agradeceu a presença do público, e concedeu ao Discente a palavra para a exposição do seu trabalho. A duração da apresentação do Discente e o tempo de arguição e resposta foram conforme as normas do Programa.

A seguir o senhor(a) presidente concedeu a palavra, pela ordem sucessivamente, aos(às) examinadores(as), que passaram a arguir o(a) candidato(a). Ultimada a arguição, que se desenvolveu dentro dos termos regimentais, a Banca, em sessão secreta, atribuiu o resultado final, considerando o(a) candidato(a):

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O competente diploma será expedido após cumprimento dos demais requisitos, conforme as normas do Programa, a legislação pertinente e a regulamentação interna da UFU.

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RESUMO

O objetivo deste estudo foi avaliar o efeito cicatrizadores revestidos com estrôncio (Sr) sobre os parâmetros clínicos peri-implantares por meio de um estudo clínico, controlado, randomizado em modelo de boca dividida. Foram selecionados 24 pacientes desdentados parciais em maxila e mandíbula, que receberam no mesmo arco dentário (2 implantes em maxila ou 2 implantes em mandíbula) dois implantes de mesmo modelo (Implante cônico com roscas compactantes, com conexão cone morse e com superfície hidrofílica) nos quais foram randomicamente instalados 1) cicatrizadores convencionais de titânio polido ou 2) cicatrizadores revestidos com Sr. Foram analisados o índice de placa visível (IPV), profundidade à sondagem (PS) e sangramento à sondagem (SS) nos períodos de 1, 2 e 3 meses após o procedimento cirúrgico. Foi executada análise da quantidade de biofilme aderido aos cicatrizadores através de microscopia eletrônica de varredura (MEV). Também foi avaliado a composição dos cicatrizadores após 3 meses do mesmo ter sido instalado na cavidade oral por meio de espectroscopia de energia dispersiva (EDS). Como resultado não se obteve diferença clínica relevante em relação à PS e IPV, no entanto, os cicatrizadores revestidos com estrôncio apresentaram menor SS na mucosa periimplantar, apesar da maior área coberta do cicatrizador revestido por Sr que foi recoberto por biofilme aderido. Os cicatrizadores revestidos com Sr, apresentaram maior presença de carbono aderido à sua superfície, bem como manteve a presença de Sr após 3 meses da utilização do mesmo em cavidade oral. Os cicatrizadores revestidos com Sr reduziram a inflamação durante a fase de osseointegração dos implantes, porém retiveram maior quantidade de biofilme aderido à sua superfície.

PALAVRAS-CHAVE: Cicatrizadores, Tratamento de superfície, mucosa peri-implantar.

ABSTRACT

The aim of this study was to evaluate the effect of strontium-coated (Sr) healing abutments on peri-implant clinical parameters through a controlled, randomized, split-mouth clinical trial. 24 partially edentulous patients in the maxilla or mandible were selected to receive in the same dental arch (2 implants in the maxilla or 2 implants in the mandible) two implants of the same model, macro and microgeometry (conical implant with compacting threads, morse taper connection and hydrophilic surface) in which were randomly installed 1) conventional polished titanium healing abutment or 2) Sr-coated healing abutment. The visible plaque index (VPI), depth on probing (DP) and bleeding on probing (BP) were analyzed at 1, 2 and 3 months after the surgical procedure. The surface area covered by biofilm adhered on the healing caps was analyzed and measured using scanning electron microscopy (SEM). The healing caps's surface's chemical composition was also evaluated after 3 months of permanence in the oral cavity by energy dispersive X-ray spectroscopy (EDS). As result, no relevant clinical difference was observed in DP and VPI, however, the strontium-coated healing caps had lower BP in the peri-implant mucosa, despite the greater coverage area of the Sr-coated healing abutment covered by biofilm. Sr-coated healing abutments showed a greater presence of carbon adhered to their surface, as well as maintaining the presence of Sr after 3 months of permanence in the oral cavity. Sr-coated healing abutments reduced inflammation during the implant's osseointegration period but retained a greater amount of biofilm adhered to their surface.

KEYWORDS: Healing abutments, peri-implant mucosa, coated abutments.

INTRODUÇÃO

A utilização dos implantes osseointegráveis é bem aceita e está bem descrita na literatura com acompanhamentos longitudinais de décadas^{1,2}. Contudo, um dos maiores desafios na implantodontia é a manutenção da saúde dos tecidos peri-implantares após a instalação dos mesmos³.

Imediatamente após instalação do implante no tecido ósseo, um processo inflamatório é iniciado para que haja o reparo da ferida. Neste processo, são iniciados vários eventos celulares e extracelulares, por meio de mediadores inflamatórios, havendo, entre outros fenômenos, a formação de rede de fibrinas que deve resultar na proliferação de fibroblastos na região supracrestal com formação de novos vasos, bem como de osteoblastos⁴. Após a cicatrização e maturação do retalho, ocorre a formação de um complexo de fibras colágenas inseridas ao osso adjacente, direcionadas paralelamente ao componente protético instalado até o tecido epitelial juncional recém-formado⁵. O íntimo contato existente entre tecido/componente promove um selamento biológico que tem papel fundamental na manutenção da osseointegração. Além disso, a integridade do epitélio juncional, por servir como a primeira barreira de proteção das constantes agressões físicas, químicas e microbiológicas, deve ser preservada para proporcionar maior longevidade e estabilidade aos implantes⁶.

O acúmulo de biofilme tem ação direta sobre a saúde dos tecidos peri-implantares. A inflamação gerada pela agressão dos patógenos presentes resulta na ativação de citocinas inflamatórias, gerando desordem e destruição das fibras colágenas do tecido conjuntivo subjacente ao epitélio juncional, podendo ocasionar migração apical do epitélio e reabsorção óssea⁷. O controle

de biofilme oral por parte dos pacientes é essencial para manutenção da saúde periimplantar, entretanto o fato de boa parte dos pacientes não possuírem habilidade e motivação suficiente para executar de forma satisfatória a higiene oral torna necessário a utilização de dispositivos que potencializem a neutralização do desafio microbiano⁸. Destaca-se nesse sentido como uma possibilidade, a utilização de agentes inorgânicos impregnados à superfície de implantes e componentes com intuito de desenvolver uma ação benéfica ao controle da ação nociva dos patógenos aos tecidos peri-implantares e auxiliar no processo de cicatrização⁹.

Dentre estas substâncias, entra em voga a utilização do estrôncio que tem sido amplamente utilizado na forma de ranelato para tratamento de pacientes com a osteoporose^{10,11}, osteoartrites¹² e a artrite reumatoide¹³ apresentando resultados positivos nessas aplicações. Como revestimento de biomateriais osteocondutores, o estrôncio já foi aplicado em biovidros^{14,15}; cerâmicas de cálcio-silicone¹⁶, enxerto homogêneo^{17,18}, fosfato de cálcio^{19,20}, hidroxiapatita^{21,22} e superfícies de implantes de titânio^{23,24}. De uma forma geral, a utilização o revestimento com o estrôncio induziu maior formação de osso novo in vivo^{15,16,19,22}, maior potencial de osteogênese in vitro^{15,16} e redução da adesão bacteriana in vitro⁹, além de se mostrar efetivo na prevenção da mineralização da placa bacteriana e da progressão de cárie sem aparente toxicidade quando usado em doses funcionais^{25,26} também sendo capaz de induzir maior proliferação de fibroblastos gengivais^{27,28}.

O processo de cicatrização ao redor de implantes bem como a manutenção da saúde peri-implantar ao longo do tempo depende de processos cicatriciais que

permitem a obtenção de um bom selamento dos tecidos peri-implantares ao redor dos diferentes componentes protéticos e periimplantares. A utilização de componentes bioativos com propriedades proliferativas e de reparação em tecido conjuntivo e antibacterianas em teoria podem beneficiar a saúde peri-implantar em diferentes momentos e, no caso dos cicatrizadores, reduzir a possibilidade de perda precoce de implantes. Dessa forma, é possível que o revestimento de cicatrizadores e pilares com estrôncio possa beneficiar a saúde na interface entre implantes e tecidos mucosos

Objetivo Geral

Avaliar o efeito do tratamento de superfície de cicatrizadores revestidos com estrôncio (Sr) sobre parâmetros clínicos peri-implantares em comparação à cicatrizadores convencionais de titânio polido (CTR)

Objetivo específico

- Avaliar o efeito do tratamento de superfície de cicatrizadores com estrôncio sobre parâmetros clínicos de Índice de placa visível (IPV), profundidade de sondagem (OS) e sangramento à sondagem (SS) em comparação à cicatrizadores convencionais de titânio polido.
- Avaliar o efeito do tratamento de superfície de cicatrizadores com estrôncio quanto à adesão de biofilme em comparação à cicatrizadores convencionais de titânio polido.
- Comparar a composição química da superfície de cicatrizadores revestidos ou não com estrôncio após 3 meses da permanência dos mesmos em meio bucal.

HIPÓTESES

HO – Cicatrizadores revestidos com estrôncio serão semelhantes aos cicatrizadores convencionais de titânio polido em relação aos resultados dos parâmetros clínicos e adesão de biofilme

H1- Cicatrizadores revestidos com estrôncio serão distintos aos cicatrizadores convencionais de titânio polido em relação aos resultados dos parâmetros clínicos e adesão de biofilme

Capítulos

Capítulo 1

ARTIGO 1

Effect of strontium-coated healing abutment on peri-implant clinical parameters. Controlled randomized split-mouth clinical trial

***Artigo em consideração no Brazilian Dental Journal**

Original Paper: Effect of strontium-coated healing abutment on peri-implant clinical parameters.
Controlled randomized split-mouth clinical trial

Short title: Strontium-coated healing abutments

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Conflict of interest

The authors declare to have no conflicts of interest regarding this study.

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Summary

The aim of this study was to evaluate the effect of strontium-coated (Sr) healing abutments on peri-implant clinical parameters through a controlled, randomized, split-mouth clinical trial. 24 partially edentulous patients in the maxilla or mandible were selected to receive in the same dental arch (2 implants in the maxilla or 2 implants in the mandible) two implants of the same model, macro and microgeometry (conical implant with compacting threads, morse taper connection and hydrophilic surface) in which were randomly installed 1) conventional polished titanium healing abutment or 2) Sr-coated healing abutment. The visible plaque index (VPI), depth on probing (DP) and bleeding on probing (BP) were analyzed at 1, 2 and 3 months after the surgical procedure. The surface area covered by biofilm adhered on the healing caps was analyzed and measured using scanning electron microscopy (SEM). The healing caps's surface's chemical composition was also evaluated after 3 months of permanence in the oral cavity by energy dispersive X-ray spectroscopy (EDS). As result, no relevant clinical difference was observed in DP and VPI, however, the strontium-coated healing caps had lower BP in the peri-implant mucosa, despite the greater coverage area of the Sr-coated healing abutment covered by biofilm. Sr-coated healing abutments showed a greater presence of carbon adhered to their surface, as well as maintaining the presence of Sr after 3 months of permanence in the oral cavity. Sr-coated healing abutments reduced inflammation during the implant's osseointegration period but retained a greater amount of biofilm adhered to their surface.

Key words: Healing abutments, peri-implant mucosa, coated abutments

Introduction

The use of osseointegrated implants is widely accepted and well-documented in the literature, with longitudinal follow-ups spanning decades^{1,2}. However, one of the major challenges in implant dentistry is to maintain peri-implant tissue's health after an implant placement³.

Immediately after the implant placement, an inflammatory process is initiated to facilitate wound healing. This process involves various cellular and extracellular events mediated by inflammatory mediators, including fibrin network formation, fibroblast proliferation, osteoblast activity, and neovascularization⁴. Following flap healing and maturation, a complex network of collagen fibers is formed, attaching to the adjacent bone and directed parallel to the prosthetic component, ultimately reaching the newly formed junctional epithelium⁵. The intimate contact between tissue and implant component promotes a biological seal, playing a crucial role in maintaining osseointegration. Additionally, the integrity of the junctional epithelium, as the first protective barrier against constant physical, chemical, and microbial aggression, must be preserved to ensure greater longevity and stability of implants⁶.

Biofilm accumulation directly affects peri-implant tissue health. The inflammation caused by the aggression of pathogens leads to the activation of inflammatory cytokines, resulting in disruption and destruction of collagen fibers in the connective tissue underlying the junctional epithelium, potentially causing apical migration of the epithelium and bone resorption⁷. Oral biofilm control by patients is essential for maintaining peri-implant health. However, since a significant portion of patients does not have the skills and motivation to perform satisfactory oral hygiene, the use of devices that enhance microbial challenge neutralization becomes necessary⁸. In this regard, the impregnation of inorganic antimicrobial agents onto implant surfaces and components to exert a beneficial effect on controlling the harmful action of pathogens on peri-implant tissues and aiding in the healing process emerges as a possibility⁹.

Among these substances, strontium has gained attention for its use in the form of ranelate for the treatment of osteoporosis^{10,11}, osteoarthritis¹² and rheumatoid arthritis¹³, showing positive results in these applications. Strontium has been applied as a coating for osteoconductive biomaterials, including bioactive glasses^{14,15}, calcium silicate ceramics¹⁶ homogenous grafts^{17,18} calcium phosphate^{19,20}, hydroxyapatite^{21,22} and titanium implant surfaces^{23,24}. In general, the use of strontium coatings has shown to induce greater new bone formation in vivo^{15,16,19,22}, increased osteogenic potential in vitro^{15,16} and reduced bacterial adhesion in vitro⁹. Strontium has also demonstrated effectiveness in preventing dental plaque mineralization and caries progression without apparent toxicity when used in functional doses^{25,26} while also inducing increased proliferation of gingival fibroblasts^{27,28}.

The healing process around implants, as well as the long-term maintenance of peri-implant health, depends on tissue healing processes that allow for a proper seal of peri-implant tissues around different prosthetic components. The use of bioactive components with proliferative and tissue repair properties, as well as antibacterial properties, theoretically benefits peri-implant health at different stages. Therefore, coating healing abutments and abutment screws with strontium may potentially benefit the health of the interface between implants and mucosal tissues, impairing the early-implants failures. Then, the objective of this study was to evaluate the clinical parameters associated with the use of healing caps coated by Sr during the osseointegration phase.

Material and methods

Patient Selection

This clinical study was a controlled, randomized, single-blind trial conducted using a split-mouth design, and its protocol was approved by the Human Research Ethics Committee of the Federal University of Uberlândia (CAAE:

52658321.1.0000.5152). Twenty-four patients participated in this study, undergoing the placement of 2 implants necessarily in the same arch, whether in the same hemi-arch or not. These patients were approached at the undergraduate and postgraduate clinics of the School of Dentistry of the Federal University of Uberlândia, and those who filled the inclusion and exclusion criteria of this study were enrolled in the project after reading, understanding, and signing the informed consent term.

The selection of patients was based on the following inclusion criteria: 1) Age between 18 and 60 years; 2) Need for bilateral unitary rehabilitation with osseointegrated implants in at least two sites in the same arch, either maxilla or mandible; 3) Sufficient bone availability for the installation of conventional-sized implants; 4) Good systemic health. Patients with the following characteristics were excluded from this study: 1) Smokers and ex-smokers; 2) Patients with diabetes mellitus; 3) Patients chronically using medications (e.g., bisphosphonates, immunosuppressants, anti-inflammatories) or with conditions that alter bone metabolism (e.g., osteoporosis, diabetes mellitus); 4) Patients chronically using anti-inflammatory and antibiotic drugs; 5) Bruxism sufferers; 6) Alcoholics; 7) Substance abusers; 8) Pregnant and lactating women; 9) History of head and neck radiation therapy.

The sample size calculation was based on the study by Lashkarizadeh et al. (2022), which evaluated the reuse of titanium healing abutments in dental implants. The primary outcome chosen was the parameter of IPV, and it was determined that the effect size of one treatment on the healing abutment compared to another to be considered clinically relevant would be 0.25. Considering that the standard deviation of this analysis method was 0.44 and setting the type I error at 0.05 and the power (beta) of this study at 0.80, it was established that a sample size of 22 patients in a split-mouth design would be sufficient to detect this level of differences between the tested healing abutments if such differences exist.

Coating Process of Healing Abutments

To perform the strontium impregnation process on the surface of the tested healing abutments, 25 healing abutments with morse taper connection from Neodent (Neodent, Curitiba, Brazil) with dimensions of 4.5 x 4.5 mm, compatible with the selected implants for this study, were sent to the University of Malmö, Sweden. There, they underwent an electrochemical anodization process to form a superficial layer of strontium nanoparticles. After this process, the healing abutments were sent back to the Federal University of Uberlândia to undergo the clinical procedures proposed by this study.

Surgical Procedure and Groups

Prior to the surgical procedure, each patient underwent full mouth disinfection. After the administration of local anesthesia, a full-thickness mucoperiosteal flap was raised to expose the ridge. The milling procedure was performed with abundant saline irrigation and according to the manufacturer's recommendations for the implants. Two Drive® implants (Neodent, Curitiba, Brazil) were installed. The selected diameter of the implants was 3.5 mm, with a length between 8-10 mm, according to the available bone height. The implant connection used was the conventional Morse taper. During implant placement, the primary stability of the implants was measured using insertion torque.

After implant insertion, the surgical site was sutured using 5.0 nylon sutures (Ethicon, Johnson & Johnson, Brazil). For all patients were prescribed amoxicillin (500 mg) for 7 days, Nimesulide (100 mg) for 5 days, and sodium dipyrone (500 mg) for 3 days for oral consumption during the postoperative period. Additionally, a mouthwash containing 0.12% chlorhexidine digluconate was prescribed for 14 days. The sutures were removed after 14 days. The therapeutic protocol did not need to be altered due to allergies to any medication reported by the patient. A total of 24 patients underwent surgery, with 12 having implants installed in the

maxilla and 12 in the mandible. All implants were placed in the premolar or molar region, with the test group being in the same hemi-arch or different from the control group but necessarily in the same dental arch.

Installation of Experimental Healing Abutments

After achieving the necessary stability, polished titanium healing abutments (control group) from Neodent brand, with Morse Taper connection compatible with the installed implants, and the same brand and model healing abutments coated with strontium (test group) were immediately installed following implant placement. The selection of the healing abutments was performed through digital randomization using a randomization table applied at the time of implant installation. The healing abutments were installed using a specific driver until a torque of 10N.cm was reached. Due to their different color and packaging, the strontium-coated healing abutments could be easily identified by the operator, thus blinding was achieved only from the patients' perspective. All patients were operated by the same operator.

Clinical Monitoring

The peri-implant clinical parameters of probing depth (PD), bleeding on probing (BOP), visible plaque index (VPI), and peri-implant mucosal inflammation index (PII) were evaluated. The probing depth was measured from the margin of the peri-implant mucosa to the bottom of the peri-implant sulcus using a titanium-tipped Williams periodontal probe (Maximus, Contagem, Brazil). The bleeding on probing index was determined by gently inserting the millimeter-marked periodontal probe into the peri-implant sulcus, and bleeding within 20 seconds after probe insertion was considered positive. The plaque index and marginal inflammation index were assessed dichotomously, considering positive those sites with visible plaque or inflammation at the peri-implant mucosal margin. These examinations were performed at 30, 60, and 90 days after the surgical procedure. PD, VPI, and PII measurements were evaluated at 4 sites per implant,

with the medial portion of each surface of the healing abutment (buccal, mesial, palatal, and distal) serving as the reference for the analysis.

Scanning Electron Microscopy Analysis

After the removal of the healing abutments, they were properly stored and prepared for examination using scanning electron microscopy (SEM). The healing abutments were stored in plastic eppendorf tubes containing 10% formaldehyde and placed in a freezer at -20°C, with one healing abutment in each tube. The preparation involved incubating the healing abutments for one hour in each solution of 70%, 80%, 90%, and 100% ethanol. Following this process, the healing abutments were mounted in pairs on metal stubs, with one from the control group and one coated with strontium, both taken from the same patient. The samples were then stored in a vacuum desiccator and taken for analysis using a Scanning Electron Microscope (SEM - Tescan brand, model BEGA 3 LMU) at the Multi-User Laboratory Network (RELAM) at the Federal University of Uberlândia, to evaluate bacterial biofilm adherence. Biofilm adherence was assessed by measuring the area of biofilm attached to the healing abutment using image analysis software ImageJ (Developed by Wayne Rasband, National Institutes of Health, USA) and by analyzing the surface composition of the healing abutments using Energy Dispersive Spectroscopy (EDS).

In addition to the images, a mapping of the chemical elements present on the surface of each sample was performed, generating a report of the quantity of these elements at different selected points on the surface of each healing abutment. This allowed for the visualization of the distribution of strontium and the biofilm adhered to the surface.

Statistical Analysis

GraphPad Prism 8 software (San Diego, CA, USA) was used for the statistical analysis of this study. The data for inflammation index (II), visible plaque index

(VPI), probing depth (PD), and biofilm adherence were tested for normality using the Shapiro-Wilk test to determine if they followed a normal distribution. Since the data for IL, VPI, and PD did not follow a normal distribution, the non-parametric Wilcoxon test was used to compare the two types of healing abutments, and the non-parametric Friedman test complemented by the Dunn's test was used to compare the data within each group across different evaluation periods. For the analysis of biofilm adherence, which followed a normal distribution, a paired t-test was performed to compare the different types of healing abutments. All tests were conducted at a significance level of 5%.

Results

Among the operated patients, 13 are female and 11 are male, all above 40 years old. There were no lost of dental implants or other types of complication during the follow-up of this study.

Clinical analysis

No differences were observed between the groups of healing abutments coated or not coated with strontium in terms of visible plaque index (VPI) and probing depth (PD). However, there was a lower degree of inflammation in the peri-implant mucosa margin associated with the healing abutments coated with strontium ($p < 0.05$). (Table 1)

Surface composition analysis of the healing abutments and biofilm adhesion

Scanning electron microscopy was used to capture images of the healing abutments at magnifications of 20, 50, 1000, and 5000 times to evaluate the abutment surface and the area covered by biofilm. The ImageJ software was utilized to calculate the area of adhered biofilm. As a result, greater biofilm adhesion and consequent surface coverage were observed on the healing

abutments coated with strontium, as shown in the graph displaying the mean values of biofilm area in each abutment group (Image 1); (Graph 1).

Energy Dispersive Spectroscopy (EDS) was employed to analyze the surface composition of the healing abutments. In these analyses, a considerable amount of carbon was detected, indicating the presence of organic matter derived from the adhered dental biofilm, which was higher in the healing abutments coated with strontium compared to the control group of polished titanium (Image 2). Additionally, the discrepancy of elements present between the test and control groups was solely due to the presence of strontium, which was uniformly distributed throughout the surface of the test abutments.

Discussion

In this study, it was observed that healing abutments coated with strontium showed similar clinical parameters of probing depth (PS) and visible plaque index (IPV) compared to the control group of polished titanium abutments. However, scanning electron microscopy revealed greater biofilm adhesion on the strontium-coated abutments, despite a lower degree of bleeding on the margins (SS) in the strontium group. Thus, the null hypothesis of this study was partially rejected.

Regarding the clinical results, both types of healing abutments proved to be effective in maintaining peri-implant mucosal health, as indicated by the assessed inflammation and probing depth values²⁹. However, a reduction in inflammation was observed in association with the use of strontium-coated abutments. This effect may be attributed to the properties of strontium ions on specific cellular groups present at the interface between prosthetic components/healing abutments and supra-crestal mucosal tissues. A previous study demonstrated that surfaces coated with strontium stimulate fibroblast proliferation and differentiation^{27,28,30}, theoretically providing the peri-implant mucosa with a greater potential to act as a primary physical barrier against microbial colonization and pathogenic action^{6,31}. In bone tissue, it has been observed that strontium stimulates osteoblast differentiation, not only promoting bone formation but also

modulating the inflammatory process by reducing the expression of pro-inflammatory markers such as IL1 β , TNF α , and PGE2^{15,16,22,32,33}. These combined effects may explain the lower clinical inflammation observed in the strontium-coated abutments. In future studies, the profile of biological markers in peri-implant crevicular fluid associated with these abutments should be investigated to test this hypothesis and determine if there were any changes in biomarker expression or if strontium demonstrated any antimicrobial properties, as described in previous studies^{9,34,35,36,37}.

Another hypothesis for the greater biofilm presence and lower inflammation index in the strontium-coated abutments is that the impregnation of the surface with strontium ions may have altered the surface roughness of the abutments, making it more favourable for biofilm adhesion^{38,39}, along with the possibility that the analyses were performed within a time period that was not sufficiently long for the coaggregation of periodontopathogens. Initial colonization is primarily carried out by streptococci, which bind to the acquired pellicle, and only in the later stages of biofilm formation do periodontopathogens play a significant role. These pathogens are not good primary colonizers of the acquired pellicle and have little participation in biofilm formation⁴⁴¹. To test this hypothesis, an analysis of the peri-implant microbiome is necessary.

The clinical results obtained in this study raise questions about the real relevance of using strontium-coated abutments, and further analyses should be conducted over longer periods than those evaluated in the present study. However, the impracticality of retaining healing abutments for extended periods of time raises the possibility of impregnating prosthetical abutments that remain in the oral cavity, allowing for analysis over considerably longer periods than those evaluated in this study. It is also necessary to assess whether the presumed increased surface roughness that may have facilitated greater biofilm adhesion on the strontium-coated abutments could eventually compromise peri-implant health, as the duration of strontium's supposed ability to modulate the expression of pro-inflammatory markers is unknown.

Limitations of the study include patient compliance with clinical follow-ups and oral hygiene care, as well as the exclusion of patients with a history of periodontal

disease, which may have contributed to the similar clinical results between strontium and conventional titanium abutments.

Conclusions

The results of this study showed that the use of strontium-coated healing abutments does not have a significant influence on the clinical parameters of probing depth and visible plaque index, despite observing higher biofilm adhesion compared to conventional polished titanium abutments. The results regarding bleeding on probing also suggest the validity of testing prosthetic abutments coated with strontium to evaluate these parameters over longer periods than those studied in this research.

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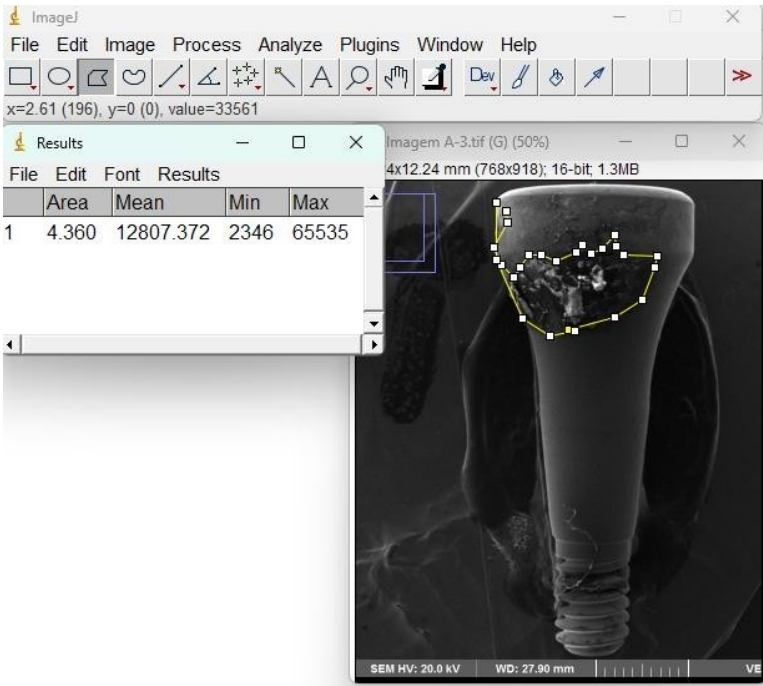
Tables

Table 1: Median data and interquartile ranges of clinical data obtained from different types of healing caps and experimental periods.

Parâmetros	IP V		II		P S	
Período / Grupos	CTR	Sr	CTR	Sr	CTR	Sr
30 d.	0.00(0.00; 0.00)	0.00(0.00; 0.00)	0.25(0.06; 0.50) ^b	0.25(0.00; 0.50)	2.25(1.81; 2.50)	2.25(1.62; 2.75)
60 d.	0.00(0.00; 0.25)	0.00(0.00; 0.25)	1.00(0.50; 1.00) ^a	0.50(0.25; 1.00) [*]	2.25(1.81; 2.93)	2.00(1.31; 2.43)
90 d.	0.00(0.00; 0.25)	0.00(0.00; 0.25)	0.50(0.25; 0.50) ^{a, b}	0.25(0.18; 0.75)	2.00(1.75; 2.50)	2.25(1.75; 3.00)

Figures

Figure 1: Demonstration of how the analysis of the area of biofilm adhered to the healing abutment was measured using the ImageJ software.



Graph 1: Graph of the mean values of the areas covered by biofilm on the Sr-coated healing abutments and in the CTR healing abutments.



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ANEXOS

Regras Revista

Revista 1

Brazilian Dental Journal

 Brasil

Brazilian Dental Journal

Instruções aos autores

Escopo e política

O Brazilian Dental Journal é um periódico científico revisado por pares (sistema duplo-cego) que publica Documentos Originais Completos, Comunicações Curtas, Relatórios de Casos e Críticas Convidadas, tratando os diversos campos da Odontologia ou áreas relacionadas, com acesso aberto. Serão considerados para publicação apenas artigos originais. Na submissão de um manuscrito, os autores devem informar em carta de encaminhamento que o material não foi publicado anteriormente e não está sendo considerado para publicação em outro periódico, quer seja no formato impresso ou eletrônico.

ENDEREÇO ELETRÔNICO PARA SUBMISSÃO:
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SERÃO CONSIDERADOS APENAS TRABALHOS REDIGIDOS EM INGLÊS. Autores cuja língua nativa não seja o Inglês, devem ter seus manuscritos revisados por profissionais proficientes na Língua Inglesa. Os trabalhos aceitos para publicação serão submetidos à Revisão Técnica, que compreende revisão linguística, revisão das normas técnicas e adequação ao padrão de publicação do periódico. O custo da Revisão Técnica será repassado aos autores. A submissão de um manuscrito ao BDJ implica na aceitação prévia desta condição. A decisão de aceitação para publicação é de responsabilidade dos Editores e baseia-se nas recomendações do corpo editorial e/ou revisores "ad hoc". Os manuscritos que não forem considerados aptos para publicação receberão um e-mail justificando a decisão. Os conceitos emitidos nos trabalhos publicados no BDJ são de responsabilidade exclusiva dos autores, não refletindo obrigatoriamente a opinião do corpo editorial.

Todos os manuscritos serão submetidos a revisão por pares. Autores e revisores serão mantidos anônimos durante o processo de revisão. Os artigos aceitos para a publicação se tornam propriedade da revista.

Brazilian Dental Journal é um jornal de acesso aberto, o que significa que todos os artigos publicados estão disponíveis gratuitamente na Internet imediatamente após a publicação.

O Brazilian Dental Journal manterá os direitos autorais e editoriais de todos os artigos publicados, incluindo traduções. Os usuários podem usar, reutilizar e construir sobre o material publicado na revista, mas apenas para fins não comerciais e desde que a fonte seja claramente e adequadamente mencionada.

A Revista adota sistema para identificação de plágio (AntiPlagiarist - ACNP Software).

O Brazilian Dental Journal está indexado na base de dados DOAJ para acesso público.

Forma e preparação de manuscritos

AS NORMAS DESCRITAS A SEGUIR DEVERÃO SER CRITERIOSAMENTE SEGUIDAS.

GERAL

- Submeter o manuscrito em Word e em PDF, composto pela página de rosto, texto, tabelas, legendas das figuras e figuras (fotografias, micrografias, desenhos esquemáticos, gráficos e imagens geradas em computador, etc).
- O manuscrito deve ser digitado usando fonte Times New Roman 12, espaço entrelinhas de 1,5 e margens de 2,5 cm em todos os lados. **NÃO UTILIZAR** negrito, marcas d'água ou outros recursos para tornar o texto visualmente atrativo.
- As páginas devem ser numeradas seqüencialmente, começando no *Summary*.
- Trabalhos completos devem estar divididos seqüencialmente conforme os itens abaixo:

1. Página de Rosto
2. Summary e Key Words
3. Introdução, Material e Métodos, Resultados e Discussão
4. Resumo em Português (obrigatório apenas para os autores nacionais)
5. Agradecimentos (se houver)
6. Referências
7. Tabelas
8. Legendas das figuras
9. Figuras

- Todos os títulos dos capítulos (Introdução, Material e Métodos, etc) em letras maiúsculas e sem negrito.
- Resultados e Discussão **NÃO** podem ser apresentados conjuntamente.
- Comunicações rápidas e relatos de casos devem ser divididos em itens apropriados.
- Produtos, equipamentos e materiais: na primeira citação mencionar o nome do fabricante e o local de fabricação completo (cidade, estado e país). Nas demais citações, incluir apenas o nome do fabricante.
- Todas as abreviações devem ter sua descrição por extenso, entre parênteses, na primeira vez em que são mencionadas.

PÁGINA DE ROSTO

- A primeira página deve conter: título do trabalho, título resumido (*short title*) com no máximo 40 caracteres, nome dos autores (máximo 6), Departamento, Faculdade e/ou Universidade/Instituição a que pertencem (incluindo cidade, estado e país). **NÃO INCLUIR** titulação (DDS, MSc, PhD etc)

e/ou cargos dos autores (Professor, Aluno de Pós-Graduação, etc).

- Incluir o nome e endereço **completo** do autor para correspondência (**informar e-mail, telefone e fax**).
- A página de rosto deve ser incluída em arquivo separado do manuscrito.

MANUSCRITO

- **O manuscrito deve conter:**

A primeira página do manuscrito deve conter: título do trabalho, título resumido (*short title*) com no máximo 40 caracteres, sem o nome dos autores.

SUMMARY

- A segunda página deve conter o *Summary* (resumo em Inglês; máximo 250 palavras), em redação contínua, descrevendo o objetivo, material e métodos, resultados e conclusões. Não dividir em tópicos e não citar referências.
- Abaixo do *Summary* deve ser incluída uma lista de Key Words (5 no máximo), em letras minúsculas, separadas por vírgulas.

INTRODUÇÃO

- Breve descrição dos objetivos do estudo, apresentando somente as referências pertinentes. Não deve ser feita uma extensa revisão da literatura existente. As hipóteses do trabalho devem ser claramente apresentadas.

MATERIAL E MÉTODOS

- A metodologia, bem como os materiais, técnicas e equipamentos utilizados devem ser apresentados de forma detalhada. **Indicar os testes estatísticos utilizados neste capítulo.**

RESULTADOS

- Apresentar os resultados em uma seqüência lógica no texto, tabelas e figuras, enfatizando as informações importantes.
- Os dados das tabelas e figuras não devem ser repetidos no texto.
- Tabelas e figuras devem trazer informações distintas ou complementares entre si.
- Os dados estatísticos devem ser descritos neste capítulo.

DISCUSSÃO

- Resumir os fatos encontrados sem repetir em detalhes os dados fornecidos nos Resultados.
- Comparar as observações do trabalho com as de outros estudos relevantes, indicando as implicações dos achados e suas limitações. Citar outros estudos pertinentes.

- Apresentar as conclusões no final deste capítulo. Preferencialmente, as conclusões devem ser dispostas de forma corrida, isto é, evitar citá-las em tópicos.

RESUMO (em Português) - Somente para autores nacionais

O resumo em Português deve ser **IDÊNTICO** ao resumo em Inglês (Summary). OBS: **NÃO COLOCAR** título e palavras-chave em Português.

AGRADECIMENTOS

O Apoio financeiro de agências governamentais deve ser mencionado. Agradecimentos a auxílio técnico e assistência de colaboradores podem ser feitos neste capítulo.

REFERÊNCIAS

- As referências devem ser apresentadas de acordo com o estilo do **Brazilian Dental Journal**. É recomendado aos autores consultar números recentes do BDJ para se familiarizar com a forma de citação das referências.
- As referências devem ser numeradas por ordem de aparecimento no texto e citadas entre parênteses, sem espaço entre os números: (1), (3,5,8), (10-15). **NÃO USAR SOBRESCRITO**.
- Para artigos com dois autores deve-se citar os dois nomes sempre que o artigo for referido. Ex: "According to Santos **and** Silva (1)...". Para artigos com três ou mais autores, citar apenas o primeiro autor, seguido de "et al.". Ex: "Pécora et al. (2) reported that..."
- Na lista de referências, os nomes de **TODOS OS AUTORES** de cada artigo devem ser relacionados. Para trabalhos com 7 ou mais autores, os 6 primeiros autores devem ser listados seguido de "et al."
- A lista de referências deve ser digitada no final do manuscrito, em seqüência numérica. Citar **NO MÁXIMO** 25 referências.
- A citação de abstracts e livros, bem como de artigos publicados em revistas não indexadas deve ser evitada, a menos que seja absolutamente necessário. **Não citar referências em Português**.
- Os títulos dos periódicos devem estar abreviados de acordo com o Dental Index. O estilo e pontuação das referências devem seguir o formato indicado abaixo:

Periódico

1. Lea SC, Landini G, Walmsley AD. A novel method for the evaluation of powered toothbrush oscillation characteristics. *Am J Dent* 2004;17:307-309.

Livro

2. Shafer WG, Hine MK, Levy BM. A textbook of oral pathology. 4th ed. Philadelphia: WB Saunders; 1983.

Capítulo de Livro

3. Walton RE, Rotstein I. Bleaching discolored teeth: internal and external. In: Principles and Practice of Endodontics. Walton RE (Editor). 2nd ed. Philadelphia: WB Saunders; 1996. p 385-400.

TABELAS

- As tabelas com seus respectivos títulos devem ser inseridas após o texto, numeradas com algarismos arábicos; **NÃO UTILIZAR** linhas verticais, negrito e letras maiúsculas (exceto as iniciais).
- O título de cada tabela deve ser colocado na parte superior.
- Cada tabela deve conter toda a informação necessária, de modo a ser compreendida independentemente do texto.

FIGURAS

- **NÃO SERÃO ACEITAS FIGURAS INSERIDAS EM ARQUIVOS ORIGINADOS EM EDITORES DE TEXTO COMO O WORD E NEM FIGURAS EM POWER POINT;**
- Os arquivos digitais das imagens devem ser gerados em Photoshop, Corel ou outro software similar, com extensão TIFF e resolução mínima de 300 dpi. Apenas figuras em **PRETO E BRANCO** são publicadas. Salvar as figuras no CD-ROM.
- Letras e marcas de identificação devem ser claras e definidas. Áreas críticas de radiografias e fotomicrografias devem estar isoladas e/ou demarcadas.
- Partes separadas de uma mesma figura devem ser legendadas com letras maiúsculas (A, B, C, etc). Figuras simples e pranchas de figuras devem ter largura mínima de 8 cm e 16 cm, respectivamente.
- As legendas das figuras devem ser numeradas com algarismos arábicos e apresentadas em uma página separada, após a lista de referências (ou após as tabelas, quando houver).

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CHECAR OS ITENS ABAIXO ANTES DE ENVIAR O MANUSCRITO À REVISTA

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3. Manuscrito (incluindo tabelas e legendas).
4. No manuscrito, observar:
 - identificação dos autores somente na página de rosto.
 - texto digitado em fonte Times New Roman 12, espaço entrelinhas de 1,5 e margem de 2,5 cm em todos os lados.
 - tabelas, legendas e figuras ao final do texto.
5. Os arquivos digitais as figuras em preto e branco, salvas em TIFF, com resolução mínima de 300 dpi.

Não há taxas para submissão e avaliação de artigos.

A Taxa de Revisão técnica é de R\$ 550,00 Reais Brasileiros (para autores nacionais) ou U\$ 200 a U\$ 250 Dólares Americanos (para autores estrangeiros) e será cobrada do autor correspondente, ainda que apenas pequenas correções no manuscrito sejam necessárias.