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Efeito de fatores combinados na tensão e perda óssea peri-implantar. Análise de elementos finitos e estudo observacional longitudinal

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Notas Preliminares

A presente dissertação foi redigida segundo o Manual de Normas para Dissertaçoes, Teses e Trabalhos Científicos da Universidade Federal de Pelotas, adotando o Nível de Descrição 3 - estrutura em capítulos não convencionais, descrita no Apêndice C do referido manual. <http://sisbi.ufpel.edu.br/?p=documentos&i=7> Acesso em: 23 de junho de 2017.

O projeto de pesquisa contido nesta tese é apresentado em sua forma final após qualificação realizada em 31 de março de 2014 e aprovado pela Banca Examinadora composta pelos Professores Doutores Noéli Boscato, César Dalmolin Bergoli e Rafael Ratto de Moraes.

Resumo

RADAELLI, Manuel Tomás Borges. **Efeito de fatores combinados na tensão e perda óssea peri-implantar. Análise de elementos finitos e estudo observacional longitudinal.** 2017. 95f. Tese de Doutorado em Odontologia - Programa de Pós Graduação em Odontologia. Universidade Federal de Pelotas, Pelotas, 2017.

Os implantes dentários têm sido bastante utilizados na reabilitação protética de espaços edêntulos devido aos excelentes resultados estéticos, biológicos e funcionais associados a alta taxa de sucesso obtida com este tratamento. Porém, a manutenção da estabilidade inicialmente adquirida pela osseointegração depende de fatores que atuam sinergicamente e incluem as características oclusais, peri-implantares e do conjunto implante-prótese. O presente estudo foi dividido em dois capítulos. No capítulo 1, a análise de elementos finitos (AEF) investigou a influência do material antagonista (dente; placa oclusal) e do comprimento e profundidade de inserção do implante (9mm instalado a nível ósseo; 11mm instalado 2mm infra-ósseo) na distribuição de tensões peri-implantares a partir da aplicação de forças oclusais normais ou parafuncionais. O capítulo 2 reporta um estudo observacional longitudinal que avaliou a influência de fatores oclusais, peri-implantares e do conjunto implante-prótese na perda óssea marginal (POM) em torno dos implantes. Para a AEF foram confeccionados 8 modelos considerando as 3 variáveis descritas. Cada modelo foi composto de uma secção de osso mandibular incluindo o segundo pré-molar, primeiro e segundo molar. No primeiro molar foram simuladas a instalação do implante a nível ósseo ou a 2mm infra-ósseo. O arco antagonista foi simulado baseando-se em 3 dentes superiores naturais, com e sem a interposição de placa oclusal. Foram aplicadas cargas oclusais normais (200N) e parafuncionais (1000N), de forma que 10% da carga total fosse acrescida a cada segundo, até completar um total de 10 segundos. Foram analisadas as tensões de von Mises sobre os implantes e componentes, e as tensões máximas principais sobre o tecido ósseo peri-implantar. As tensões foram concentradas principalmente na interface implante-prótese e implante-osso, com valores mais altos observados quando forças parafuncionais atuavam sem a interposição da placa oclusal. A placa oclusal redirecionou as forças oclusais e diminuiu os níveis de tensão em todas as estruturas avaliadas, exceto no osso trabecular. A inserção infra-óssea do implante de 9mm reduziu o nível de tensão na interface implante-prótese e na superfície da crista óssea cortical, porém aumentou na interface implante-osso. No estudo observacional longitudinal foram avaliados 33 indivíduos, com 109 implantes cone morse instalados. Foram realizadas radiografias no momento da instalação do implante e após 12 meses de carregamento protético. Fatores oclusais, peri-implantares e do conjunto implante-prótese foram avaliados clinicamente no início do carregamento protético e após 12 meses. As variáveis foram analisadas pelo modelo analítico “Three Age” e Chi-quadrado (α=0.05). Uma análise multinível de efeito misto, com dois níveis, foi utilizada para estimar os valores preditivos de cada modelo analítico. Foram observados maiores níveis de POM para próteses cimentadas, diâmetro do implante de 3,5mm, altura da papila até 2mm, mucosa queratinizada inferior a 3mm, comprimento dos implantes superiores a 8,5mm, padrões oclusais inadequados, presença de sangramento à sondagem e bolsas profundas. Embora os dados relacionados aos implantes tenham sido mais frequentemente associados à POM no primeiro nível, os fatores peri-implantes e oclusais também exerceram influência.

Palavras-chave: implantes dentários; análise dos elementos finitos; reabsorção óssea; bruxismo do sono; placas oclusais.

Abstract

RADAELLI, Manuel Tomás Borges. **Effect of combined factors on peri-implant stress and bone loss. Finite element analysis and observational longitudinal study.** 2017. 95p. Thesis PhD in Dentistry. Graduate Program in Dentistry. Federal University of Pelotas, Pelotas, 2017.

The dental implants have often been used for the prosthetic rehabilitation of edentulous areas due to the excellent esthetic, biologic, and functional results associated with the high success rate for this treatment. However, the maintenance of initial stability obtained with osseointegration depends on factors acting synergistically and include the occlusal, peri-implant, and implant-prosthetic characteristics. The present study was divided into two chapters. In Chapter 1 the finite element analysis (FEA) assessed the influence of the antagonist occlusal material (teeth; occlusal splint), implant length and insertion depth (9mm at equicrestal; 11mm at 2mm subcrestal) on stress distribution in peri-implant bone tissues and implant-abutment connection for normal and parafunctional occlusal forces. The Chapter 2 reports an observational longitudinal study that assessed the influence of occlusal, peri-implant and implant-prosthetic factors on implant marginal bone loss (MBL). Considering the 3 described variables, 8 models were constructed for the FEA. Each model was composed of a mandibular bone section including the second premolar, first and second molar. At the first molar, equicrestal and 2-mm subcrestal implant insertion depths were simulated. The antagonist arch was simulated based on three natural maxillary teeth crowns with and without the occlusal splint interposition. Normal (200N) and parafunctional occlusal forces (1000N) were applied, increasing 10% of the full loading per second, until 10 seconds. von Mises stresses and maximum principal stresses were analyzed for titanium components and peri-implant bone tissues, respectively. Stress was mainly concentrated in the abutment-implant and implant-bone interfaces. Models loaded with parafunctional forces and without acrylic resin occlusal splint showed the highest stresses values. Occlusal splint changed the pattern of stress distribution and decreased stress levels for all structures assessed, except in the trabecular bone. Subcrestal insertion of the 9-mm implant provided reduced stress in the implant-abutment interface and coronal bone crest, while increased the stress in the implant-bone interface. In the observational study, 33 individuals with 109 cone morse implants were evaluated. Implants were radiographically examined at surgery and 12 months after prosthesis loading. Implant-prosthetic, peri-implant, and occlusal factors were assessed clinically at one month and 12 months after prosthesis loading. Independent variables were analyzed by decision tree analysis using the classification and regression tree and Chi-squared automatic interaction detection. Two-levels multilevel mixed effect analysis was used to estimate predictive values of each analytical model (α= 0.05). Highest levels of MBL were found for cement-retained prosthesis, platform diameter of 3.5mm, papilla sizes up to 2mm, keratinized gingival width up to 3mm, implant lengths above 8.5mm, inadequate occlusal pattern, presence of bleeding on probing and deeper pocket. Even though implant-related data appeared more frequently associated with MBL in the first level, peri-implant and occlusal-related factors also influenced.

Keywords: dental implants; finite element analysis; bone resorption; sleep bruxism; occlusal splints.

Sumário

1 Introdução

O tratamento com implantes dentários é amplamente utilizado quando faz-se necessária a reposição de elementos dentários ausentes ou condenados à extração (KOMIYAMA et al., 2012). A introdução de seu uso no campo da odontologia é considerado um marco no tratamento de pacientes total ou parcialmente edêntulos (KOMIYAMA et al., 2012; PAPASPYRIDAKOS et al., 2012), desde a sua origem na década de 60 a partir da descoberta da osseointegração, onde alcançou taxas de sucesso em torno de 81% à 91% (ALBREKTSSON et al., 1981), até os dias atuais onde estas taxas variam em torno de 93,1 à 100% (ASTRAND et al., 2008; ROMEO; STORELLI, 2012; JUNG et al., 2012; PJETURSSON et al., 2012; PRIEST et al., 2014). A osseointegração é definida como a formação de uma interface direta entre osso e implante, sem a presença de tecido fibroso, e determina um dos parâmetros mais importantes para se avaliar o sucesso e a longevidade desta modalidade de tratamento (KOMIYAMA et al., 2012; SAKKA et al., 2012).

No entanto, apesar destas altas taxas de sucesso observadas na osseointegração de implantes dentários, complicações mecânicas e biológicas podem ocorrer em função de fatores pré-estabelecidos, conhecidos como fatores de risco (BRAGGER et al., 2005; ROSENTRITT et al., 2011; PAPASPYRIDAKOS et al., 2012; PRIEST et al., 2014). As complicações mecânicas envolvem as fraturas de implantes, de conexões protéticas, de parafusos fixadores ou estruturas da prótese, assim como o afrouxamento do parafuso de fixação, o desgaste dos dentes e a perda da restauração de selamento do orifício de acesso ao parafuso (JEMT, 1991; BRAGGER et al., 2005; MALÓ et al., 2011; JUNG et al., 2012; SCHNEIDER et al., 2012). Já como complicações biológicas, são definidas aquelas que dificultam a osseointegração e afetam os tecidos que suportam os implantes, tais como a inflamação, o sangramento, a supuração da mucosa, as lesões de tecido mole (proliferação gengival, fenestrações, deiscências e fístulas), a perda óssea marginal (POM) em torno do implante e os distúrbios sensoriais (GERVAIS; WILSON, 2007; JUNG et al., 2012; BARRACHINA-DÍEZ et al., 2013). Se divididas de acordo com critérios cronológicos, as complicações biológicas podem ser denominadas de precoces ou tardias, sendo que as precoces ocorrem quando simplesmente não é obtida osseointegração do implante, o que pode indicar interferência no processo de cicatrização óssea inicial, enquanto que as tardias estão relacionadas a não manutenção da osseointegração (ESPOSITO et al. 1998; SAKKA et al., 2012).

É preciso ressaltar que é comum uma perda óssea inicial em torno do implante após a obtenção da osseointegração e da instalação da prótese dentária, desde que não ultrapasse 1,0 mm no primeiro ano de função e 0,2 mm anuais, nos anos seguintes (ALBREKTSSON et al., 1986). Esta perda óssea aceitável ocorre devido aos vetores de forças oclusais direcionadas ao osso, o qual responde mecanicamente a essa situação, remodelando-se naturalmente (HOSHAW et al., 1994; GROSS, 2008; KLINEBERG et al., 2012). No entanto, quando a perda de nível ósseo marginal atinge níveis maiores que os normalmente observados no primeiro ano e anos subsequentes, é possível que fatores de risco, mecânicos ou biológicos, estejam somando aspectos que podem culminar em perda da osseointegração (QIAN et al., 2012; DALAGO et al., 2017; DE ANGELIS et al., 2017; CHRCANOVIC et al., 2017). Reconhecer e prevenir quaisquer fatores que possam levar a um possível risco de fracasso no tratamento com implantes deveria nortear o clínico, pois as consequências decorrentes da falha do implante são financeira e biologicamente onerosas ao paciente.

Dentre os fatores de risco que afetam a osseointegração, dois fatores etiológicos primários são bastante conhecidos como causadores de perda óssea peri-implantar, a infecção bacteriana (teoria da placa) e a sobrecarga biomecânica (teoria da sobrecarga) (ISIDOR, 1997). Enquanto parece que a carga mecânica isoladamente não é capaz de provocar reabsorção óssea progressiva, a sobrecarga mecânica associada à presença de infecção marginal certamente pode, pois em conjunto funcionam como um fator etiológico de POM, similar àquela situação que ocorre com os dentes naturais (MIYATA et al., 2002; KOZLOVSKY et al., 2007; FU et al., 2012; KLINEBERG et al., 2012).

Neste contexto, é importante salientar que a oclusão, embora ainda pouco avaliada em estudos clínicos longitudinais, pode ser um fator crítico para a longevidade do conjunto implante-prótese, devido à natureza da carga potencial criada por contatos de dentes sobre a fixação do implante de titânio ao osso (KIM et al., 2005; BEN-GAL et al., 2013). Na dentição natural, o ligamento periodontal tem a capacidade de absorver o estresse ou permitir o movimento do elemento dental, mas a interface osso-implante aparentemente não tem essa capacidade (ASHMAN; VAN BUSKIR, 1987; CHAPMAN, 1989; KIM et al., 2005; BEN-GAL et al., 2013).

Do ponto de vista dos fatores de risco oclusais, o bruxismo poderia providenciar considerável sobrecarga sobre os implantes, tendo em vista que é uma atividade motora caracterizada por rangimento ou apertamento dos dentes, que culmina em excessiva carga oclusal. Esta parafunção tem sido apontada como um dos fatores de risco capazes de afetar os resultados de sucesso do tratamento com implantes, uma vez que culmina em complicações mecânicas às próteses implantossuportadas (NAERT et al., 1992; PEREL et al., 1994; ESPOSITO et al., 1998; ECKFELDT et al., 2001; GLAUSER et al., 2001; TOSUN et al., 2003; VAN DER ZAAG et al., 2007; GROSS, 2008; MALÓ et al., 2011; MANFREDINI et al., 2011; FU et al., 2012; KOMIYAMA et al., 2012). As consequências oclusais ocasionadas pelo rangimento e apertamento frequentes, já foram previamente relatadas quando pacientes dentados foram avaliados (JOHANSSON et al., 2011). Por outro lado, ainda há falta de evidências científicas e estudos clínicos relevantes que atestem os efeitos do bruxismo como causa da POM em implantes e suas sequelas em reabilitações implantossuportadas (MANFREDINI et al., 2014; CHRCANOVIC et al., 2015). Essa falta de evidência pode ocorrer devido à dificuldade em se isolar o bruxismo como possível fator complicador do tratamento com implantes (LOBBEZOO et al., 2006). Mesmo assim, há no meio literário autores que baseados na prática clínica, e estudos realizados em dentados, têm indicado o uso de placas oclusais como prevenção da sobrecarga oclusal nos implantes de pacientes bruxômas (NAERT et al., 1992; PEREL et al., 1994; BRAGGER et al., 2001; MCCOY, 2002; TOSUN et al., 2003, PASSANEZI et al., 2017). Contudo, não há na literatura evidência científica alguma de que o uso destes dispositivos tenha efeito preventivo na POM de implantes instalados em indivíduos bruxômas (LOBBEZOO et al., 2006; MANFREDINI et al., 2014; MESKO et al., 2014). De fato, tanto o fator sobrecarga oclusal quanto o uso de placa oclusal representam fatores difíceis de serem isolados em estudos clínicos, devido a dificuldade para avaliação da sua frequência e tempo de uso, o que poderia originar inadequada mensuração da real POM originada em função do uso ou não deste dispositivo.

No entanto, embora com as dificuldades inerentes a este tipo de avaliação, é imprescindível que se conheça como as tensões resultantes das cargas oclusais são transmitidas, dissipadas ou neutralizadas pelo sistema de implante (MORNEBURG et al., 2000; BOZKAYA et al., 2004; TEIXEIRA et al., 2012; TORCATO et al., 2015), visto que todo o complexo formado por osso-implante-prótese pode estar sujeito a falhas decorrentes de um possível excesso de carregamento (TOSUN et al., 2003; MANFREDINI et al., 2014; CHRCANOVIC et al., 2016, PASSANEZI et al., 2017). Como os materiais que atuam como antagonistas de próteses implanto-suportadas possuem diferentes propriedades físicas, como é o exemplo das cerâmicas, resinas acrílicas ou até mesmo estruturas dentárias, estes podem transmitir diferentes quantidades de carga quando em função oclusal e, conforme suas propriedades, podem induzir níveis variados de estresse ao tecido ósseo peri-implantar (MENINI et al., 2013). Como a padronização de fenômenos físicos em um estudo clínico e a avaliação realística das tensões em estudos laboratoriais são tarefas difíceis de serem realizadas (SRIREKHA; BASHETTY, 2010; QIAN et al., 2012), a utilização de um método que providencie estas características, tal como o método de elementos finitos, tem sido a escolha de muitos pesquisadores (BOZKAYA et al., 2004; SRIREKHA; BASHETTY, 2010; TORCATO et al., 2015). Porém, mesmo apresentando algumas vantagens sobre outros métodos de avaliação, o método de elementos finitos deve ser utilizado sempre como um auxiliar na compreensão dos fatores físicos, buscando embasar alguns resultados clínicos não muito compreendidos, e nunca como um desfecho realístico em si (SRIREKHA; BASHETTY, 2010).

Contudo, a literatura também apresenta controvérsias a respeito da associação de fatores peri-implantares com a POM. A espessura da mucosa queratinizada é apontada em alguns estudos como um fator com forte influência na POM (LINKEVICIUS et al., 2015; PUISYS et al., 2015; OH et al., 2017), já em outros, sua variação de espessura não resultou em diferenças significativas (CHUNG et al., 2006; LIN et al., 2013; CANULLO et al., 2017). Ainda, têm sido associados com a remodelação óssea ao redor do implante o manuseio do implante, o trauma cirúrgico e a experiência do operador, o espaço biológico, e a relação entre o implante e o pilar protético (QIAN et al., 2012; CHRCANOVIC et al., 2014; ALBREKTSSON et al., 2017).

Assim, fica claro que o conhecimento sobre os fatores preditivos ao risco da osseointegração e o entendimento de como atuam de forma associada é essencial para o estabelecimento de um protocolo de tratamento para pacientes bruxômas, que seja compatível com o sistema estomatognático e que preserve a integridade, estabilidade e função dos implantes e próteses sobre implante a longo prazo (QIAN et al., 2012; CHRCANOVIC et al., 2014; ALBREKTSSON et al., 2017). Dessa forma, a elaboração de estudos *in vivo* e *in vitro* avaliando tais aspectos tem grande relevância científica, uma vez que há escassez de pesquisas abordando os aspectos acima discutidos (JOHANSSON et al., 2011; KLINEBERG et al., 2012; FU et al., 2012; KOMIYAMA et al., 2012; SARMENTO et al., 2012; BEN-GAL et al., 2013; MANFREDINI et al., 2014; CHRCANOVIC et al., 2015, SHERIDAN et al., 2016). Portanto, o objetivo deste estudo foi desenvolver um estudo observacional longitudinal e um estudo *in vitro* baseado na tecnologia de elementos finitos para avaliar o efeito combinado dos fatores oclusais, peri-implantares e relativos às características dos implantes nas tensões e perdas ósseas peri-implantares. Foram testadas as hipóteses (i) que o material antagonista, a carga, a inserção e o comprimento do implante teriam influência na concentração de tensões no tecido ósseo peri-implantar e estruturas do implante, e (ii) que a perda óssea peri-implantar seria influenciada por fatores de risco relacionados às características oclusais, peri-implantares e relativas ao conjunto prótese-implante.

2 Capítulo 1[1]

Parafunctional loading and use of occlusal splint on stress distribution around implants: A nonlinear 3D finite element analysis

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ABSTRACT

Statement of problem. The use of occlusal splint is frequently recommended in bruxism patients to protect implant-supported treatments. However, there is limited evidence based studies for this indication.

Purpose. This finite element analysis evaluated the influence of the acrylic resin occlusal splint interposition, and of the implant length and insertion depth, on stress distribution at periimplant bone tissues and implant-abutment connection at normal and parafunctional occlusal simulations.

Material and methods. A mandibular bone section including the second premolar, first and second molars were simulated for each finite element model (n=8). At the first molar, two implant insertion depths were simulated: bone level and 2-mm subcrestal. The antagonist arch was simulated with three natural maxillary teeth crowns, with and without interposition of acrylic resin occlusal splint. Normal (200-N axial and 10-N oblique load) and parafunctional forces (1000-N axial and 25-N oblique load) were applied in a nonlinear condition, using 10% of the total amount per second until ten seconds. Maximum principal stress and von Mises stress were evaluated.

Results. Stress concentrations were mainly in the abutment-implant and implant-bone interfaces. Models loaded with parafunctional forces and without occlusal splint interposition showed the highest stresses values. Occlusal splint interposition changed the pattern of stress distribution and decreased stress levels in all structures, except in the trabecular bone. Subcrestal insertion (9mm length implant) provided reduced stress in the implant-abutment interface and cortical bone coronal to the implant platform; while increased the stress in the bone in contact with implant surface.

Conclusions. Parafunctional forces highly increased stress levels. Occlusal acrylic resin splint decreased stress levels in the abutment and implant and led to more uniform stress distribution between cortical and trabecular bone. Implant length and insertion depth influenced the stress levels in the abutment, implant, and bone tissues.

CLINICAL IMPLICATIONS

The use of occlusal acrylic resin splint for bruxism patients treated with implants could protect prosthetic components, implants, and bone tissues of deleterious stresses induced by parafunctional forces. The implant placement at 2-mm subcrestal created lower stress concentration in the coronal periimplant bone tissue.

INTRODUCTION

Occlusal splints are recommended to minimize the parafunctional contacts and occlusal overload to the interface between bone and implant in individuals with bruxism habits containing implant-supported prostheses.[1,2,3,4,5] This recommendation could represent an overtreatment since the real efficacy and effectiveness of the approach are unsupported by well-designed, randomized controlled clinical trials.[6] Nonetheless, clinical experience suggests that occlusal overload in prostheses-wearing individuals may elicit adverse time-dependent mechanical[1,7] and biological[7,8] complications.

In additon, studies have reported that implant insertion depth[9,10] and length[11-14] could also influence the marginal bone loss and longevity of implant-prosthesis system.[15,16] This occurs because different implant length and insertion depth provides contact area with different bone densities, influencing the long-term bone maintenance.[9,10]

The stress concentration pattern between bone and implant interface have been assessed by electrical wire resistance strain gauge,[10,12,17] photoelasticity,[17,18] and finite element analysis (FEA) methods.[9,10,12-14,19-22] Occlusal load simulations based on FEA had generated increasing interest in dentistry for testing different alternative techniques and materials in commonplace.[23-26]

Although several aspects concerning implant failure and periimplant bone loss have been reported,[1,15,27] there is still a lack of clinical investigations on humans considering the role of occlusal overload associated with implant length and insertion depth parameters on stress distribution around implants. This study reflects the effort to produce scientific evidence corroborating the recommendation of occlusal splint wearing after implant therapy in patients with bruxism. Therefore, this 3-dimensional (3D) FEA assessed the influence of the occlusal splint interposition and implant characteristics (length and insertion depth) on stress distribution at periimplant bone tissues and implant-abutment connection loaded with normal and parafunctional occlusal simulations. The hypotheses tested were that (i) parafunctional loadings would induce higher stress concentrations in all outcomes; (ii) occlusal splint interposition would decrease the stress intensity in all outcomes; and (iii) use of a shorter implant to insert the platform 2-mm subcrestally would produce lower stress concentration in the cortical periimplant bone tissue.

MATERIALS AND METHODS

Three factors were under investigation in this FEA study: occlusal force at two levels (normal and parafunctional), occlusal splint interposition (with or without use of acrylic resin occlusal splint), and implant length and insertion depth at two levels (11mm length implant at bone level position and 9mm length implant at 2-mm subcrestal) (Table 1). A qualitative nonlinear FEA was used to determine the stress levels in bone tissue, implant, and prosthetic abutment.

Mandibular bone section including the second premolar, first and second molars were simulated for each finite element model (n=8). The morse taper implant system (Titamax CM Cortical; Neodent) at the first molar region was combined with an abutment (CM Universal Abutment; Neodent) supporting a cemented porcelain-fused-to-metal crown. Two implant insertion depths were simulated: at bone level (Fig. 1A) and 2-mm subcrestally (Fig. 1B), with 11- and 9-mm implant lengths, respectively. The abutment was created according to the implant installation depth to maintain the prosthetic crown shoulder at the same distance of the cortical bone: bone level (4.5 mm of diameter x 4 mm height x 1.5 mm of gingival height); and 2-mm subcrestal (4.5 mm of diameter x 4 mm height x 3.5 mm of gingival height). The antagonist arch was simulated based on three natural maxillary teeth crowns of the second premolar, first and second molar. The maxillary crowns were attached at the cervical level to a solid block (35-mm length x 16.8-mm width x 4.7-mm height) consisting of cortical bone where the loadings were applied (Fig. 1C). Simulating the use of occlusal splint, four models have an acrylic resin material (minimum of 2-mm thickness) covering the occlusal surface of the maxillary teeth (Fig. 1D). All models were loaded with normal and parafunctional occlusal forces.

The bone block and natural teeth models were obtained with computer tomography from the sagittal section of a human mandible in the left posterior region by using 3D medical imaging reconstruction software (InVesalius 3.0; CTI Renato Archer).[28] The bone was classified as type II[29] with cortical bone thickness presenting in average 2.53 mm around dental implant. Computer-aided design (CAD) images of the implants and prosthetic components were supplied by the manufacturer (Neodent) (Fig. 2). The implant-supported crown was modeled in 3D modeling software (Rhinoceros 5.0, NURBS modeling for Windows; Robert McNeel & Associates) with the mandibular first molar crown and prosthetic abutment surfaces as external and internal format references. The solid antagonist block where loadings were applied, the occlusal acrylic resin splint, and the periodontal ligaments were also created and modeled with the 3D modeling software.

After the modeling phase, all the 3D models were exported to finite-element software (Simlab; Altair Engineering) for mesh generation, definition of material properties, boundary and loading conditions. All involved structures were meshed with 10-nodes tetrahedral elements, with mechanical properties determined by values obtained from published reports (Table 2). All regions evaluated with possible stress concentration were manually refined. Manual control is required to improve the mesh through the selective distribution of elements and sizes. All materials were assumed to be linearly elastic, homogeneous, and isotropic.

Constraint definitions were established as fixed in the *x*, *y*, and *z* axes at the distal surface of the bone block (Fig. 3A), and as symmetrical in the *x*, *y*, and *z* axes at the mesial surface (Fig. 3B). All other model surfaces were unrestricted (Fig. 3C). Bonded contact was set for all interfaces among different structures but the external surfaces of prosthetic, and natural teeth crowns. It was assumed that full osseointegration was achieved at bone-implant interface and that residual stress developed in the abutment and implant during assembly had relaxed.[9]

The normal and parafunctional occlusal forces were simulated applying respectively 20-N axial/1-N oblique and 100-N axial/2.5-N oblique loads per second until completing ten seconds. The normal and parafunctional occlusal forces reached final 200-N axial/10-N oblique and 1000-N axial/25-N oblique loadings, respectively.[22] The final 10-N normal oblique load was a resultant loading of vectors with -5.24 N in the *x* axis, -6.25 N in the *y* axis, and +5.77 N in the *z* axis. The final 25-N parafunctional oblique load was a resultant loading of vectors with -14.4 N in the *x* axis, -15.5 N in the *y* axis, +13.17 N in the *z* axis. As the simulation were not converging, the oblique loadings needed to be 5% and 2.5% of the axial loadings, respectively, with a nonlinear application of loads simulating a time-step condition. It allowed adaptation of the structures according to the transfer of loadings without bonding the occlusal surfaces. The loads were applied in a distributed way along all the top surface of the maxillary solid block (Fig. 3). Occlusal contact against teeth and prosthetic crown were considered to have the same intensity and supporting cusps occluded with antagonist fossa and marginal ridges.

The FEA software (Simlab; Altair Engineering) was used to obtain von Mises stress (MPa) for titanium abutments and implants, due to the ductile nature, and maximum principal stress (MPa) for bone tissues, as they are friable materials. Positive values of maximum principal stress represent tensile stress, and negative values represent compressive stress. Furthermore, displacement maps (mm) were plotted for comparative analysis of all models coherence.

RESULTS

The maximum principal stress distribution for periimplant trabecular and cortical bone are shown in Figure 4. The highest values were located mainly at the interface with implant surface when under parafunctional forces without use of occlusal splint (Figs. 4E and 4G), where the cortical bone concentrated higher tensile values and trabecular bone showed higher compressive values.

The von Mises stress distribution for implant and abutment are shown in Figures 5 and 6. Patterns of stress distribution were similar under normal and parafunctional occlusal forces among the 8 models evaluated (Compare the upper half to the lower half of the Figs. 4, 5 and 6). Load increasing yielded linear increase of the stresses with highest stress values under parafunctional forces in all models and structures. The occlusal splint interposition (Right half of the Figs. 4, 5 and 6) modified the stress distribution patterns. When parafunctional loadings were present the use of occlusal splint decreased tensile stress levels in the cortical bone, and increased compressive stress levels in the trabecular bone (Compare Figs. 4E to 4F, and 4G to 4H). The same decreasing effect yielded by the occlusal splint was observed in abutments and implants overloaded by the parafunctional forces (Compare the lower left half to the lower right half models of Figs. 5 and 6).

The association of longer implant and bone level insertion under parafunctional forces (Model 5) showed highest von Mises stress values at abutment and implant (Figs. 5E and 6E), originating highly concentrated tensile stress in the cortical bone, and lower tensile stress in the trabecular bone (Fig. 4E). The occlusal splint insertion (Model 7) reduced the stress levels in all structures (Figs. 4F, 5F, and 6F) with exception to trabecular bone, where increased stress was observed in contact with the implant threads tip (Fig. 4F). The association of shorter implant with 2-mm subcrestal insertion under parafunctional forces (Model 6) showed higher tensile stress concentrations in the cortical bone in contact with implant shoulder, and intermediate tensile stresses in trabecular bone in contact with implant threads tip (Fig. 4G). The deeper insertion of the shorter implant when under parafunctional forces (Model 6 and 8) decreased the tensile stresses concentration in the top surface of the cortical bone (Compare Figs. 4E to 4G, and 4F to 4H). The use of occlusal splint (Model 8) showed little influence for decreasing stress levels of shorter implantes inserted 2-mm subcrestally when under parafunctional forces (Compare Figs. 4G and 4H). This result suggests that occlusal splint showed better effectiveness on decrease stress distribution for longer implant and bone level insertion depth combination.

The use of occlusal splint significantly modified the displacements pattern. Expressive intrusion (displacement from occlusal to apical), sliding (displacement from mesial to distal), and slight flexion (displacement from lingual to buccal) were observed in the implant-prosthetic set when natural teeth were the antagonist material. The occlusal splint interposition changed contacts distribution on occlusal surfaces, thereby significantly decreasing the displacements intensity and flexion movements of the implant-prosthetic set. The predominantly intrusive movements transferred the stress intensity more apically, from the implant platform level to the abutment first thread region (Compare Fig. 5E to 5F, and 5G to 5H), and from cortical to the trabecular bone in the implant-bone interfaces (Compare Fig. 4E to 4F, and 4G to 4H).

DISCUSSION

The hypotheses tested were partially accepted because the parafunctional occlusal loadings increased the stress levels in all structures, and overall the use of occlusal splint decreased the stress intensity in all outcomes. In addition, subcrestal insertion of the implant platform decreased stress concentration at the coronal surface of the cortical bone and abutment-implant interface but did not at bone in contact with implant surface.

The high stress levels at abutment-implant interface, and at bone in contact with implant surface that were observed in this study are similar to the effect verified by previous reports.[3,9,22,24] Probably, this is a situation usually found in implant treatments because dental implants lack a periodontal ligament, resulting in limited implant mobility and muscles proprioceptive feedback, unlike natural teeth.

These findings also demonstrated that all tested variables (loading, occlusal splint interposition, and implant length and insertion depth) influenced the load transfer to the abutment, implant, and bone tissues. Among these variables, the occlusal force was the most dominant factor affecting the stress intensity for all structures and materials evaluated; and parafunctional loading significantly increased the stress levels. The occlusal free of splint interposition yielded horizontal force vectors and nonaxial loads on the mandibular structures corroborating previous studies that also reported the development of higher stress levels in bone tissue when oblique loads were applied.[13,21,22] The association of parafunctional loadings without occlusal splint interposition produced the highest stress levels in the abutments, implants, and periimplant bone tissues. In addition, this combination was more significant in the abutment-implant interface and cortical bone of the longer implant inserted at the bone level position, and in the cortical and trabecular bone in contact with the threads of the shorter implant inserted subcrestally.

When there is no use of occlusal splint, the insertion at bone level produced higher stress concentrations above the level of trabecular bone tissue, increasing the stress levels in the abutment-implant interface and cortical bone surface. However, higher stress concentrations below the implant platform level was observed with subcrestal insertion, overloading only bone tissue in contact with implant threads. This finding probably occurred due to higher contact area between the cortical bone and implant when insertion depth was at bone level, [9,10,13] resulting in higher cortical fixation than subcrestal insertion. Previous studies showed that higher implant insertion depth[9,10,13] significantly reduced the stress values between the implant shoulder and crestal bone. These reports are in agreement with the results observed in this mathematical model. In contrast, Huang et al. (2011) found lowest stress values for equicrestal when evaluated subcrestal, equicrestal and supracrestal insertion depths. However, compressive stress values were analyzed instead of tensile stress.

The use of occlusal splint modified the contact distribution on occlusal surfaces changing the stress distribution and displacement patterns; the force vectors yielded a vertical and intrusive movement as previously related.[2] The intrusive resultant produced by occlusal splint decreased the stress intensity produced by parafunctional forces, suggesting that the use of occlusal splint could protect implant-prosthesis system in bruxism individuals. Reduced stress levels with use of occlusal splint have also been reported in previous photoelastic evaluation.[18] Moreover, a retrospective clinical study suggested that the opposing structure plays a significant role in marginal bone levels around implants.[27] These results are in line with studies reporting that occlusal overload can cause implant complications[1,7] and failures.[7,8]

Occlusal splint resulted in more evident reduced stress levels for bone level than subcrestal insertion depth, and at the implant and abutment than at cortical and trabecular bone tissues. Indeed, the better effectiveness of occlusal splint on stress distribution in the models involving longer implant and bone level insertion depth combination occurred due to modification of flexural to intrusive displacement, what did not happen when the shorter implant was inserted subcrestally. Therefore, for this combination, the stress concentrations occurred manily below the implant platform level, transfering from the abutment-implant interface to the trabecular bone. Nevertheless, it is not known if these findings were due to subcrestal implant insertion or short implant length, although previous studies reported that shorter implants produced higher levels of stress in bone tissues, mainly in low-density bone models.[19,24] In the future, studies must compare different implant lengths and insertion depths to address where the bone density in contact with implant or the quantity of contact between implant and bone is the responsible for this results.

Nonetheless, although *in vitro* studies were proposed to produce scientific evidence regarding the relationship between parafunctional habits and osseointegration, the number of published studies is still scarce, characterized by low level of scientific evidence, and most of them deal with a limited number of cases without a control group.[1,2] A previous systematic review[6] concluded that the recommendation to use occlusal splints to protect the implant-supported rehabilitation in subjects with bruxism is supported only by a case report and expert opinions.[3-5] Probably based on this rationale, several dentists prescribe night-time use of occlusal splint in patients with bruxism habits to minimize the occlusal overload and avoid biological and biomechanical complications. However, to the best of author's knowledge this is the first 3D nonlinear FEA that investigated the influence of occlusal splint as antagonist material of implant-prosthetic rehabilitation on implant-bone stress distribution.

The application of normal and parafunctional occlusal force intensity did not alter the pattern of stress distribution through the implant-bone interface, which has also been observed in previous FEA studies.[22,24] Results of the present study are in agreement with studies[20,22,24] reporting that overload increases stress concentrations at the periimplant bone tissue. However, in these studies the load distribution is simplified along the occlusal surface of implant-supported prosthesis, and it is considered that stress concentration is a linear result of implants loaded instantaneously, without taking into account the contact with different materials in the antagonist arch and nonlinearities that this situation may present.[20]

One of the strong point of this study was that loads were applied in a time-step condition instead one-time loading. It allowed the different structures to adapt and transfer the load between each other over the time without being bonded, thus avoiding nonconvergences or use of loadings fixed in some axes at teeth occlusal surfaces. The validity of linear static analysis may be questionable when the study objectives are to explore more realistic situations that are usually found in the intraoral environment. Nonlinear analysis has become an increasingly powerful approach to predict stress and strain within structures in a real situation that cannot be solved by a linear static model.[25,26] However, this study is not free of limitations and the results should be interpreted with caution. It was assumed that all materials used in this study were linear elastic, isotropic, and homogeneous; 100% osseointegration was simulated at bone-implant interface, and that residual stress developed in the abutment and implant during assembly had relaxed. The periodontal ligament dynamic behavior and coefficients of friction between different materials contact were not simulated. The occlusal contact between tooth and Further studies should be performed to assess the influence of splinted ceramic as antagonist occlusal material in individuals with bruxism habits and their effects on marginal bone loss.

CONCLUSIONS

Parafunctional loading increased the stress levels in all structures when compared with normal loadings. Occlusal splint interposition resulted in lower stress levels at abutment and implant, and better distribution of lower stresses between cortical and trabecular bone. The protective effect of occlusal splint when simulating parafunction was more evident when the implant was inserted at bone level. When parafunction was simulated without the use of occlusal splint, the insertion of implant platform at 2-mm subcrestally yielded more favorable biomechanical condition for abutment-implant interface and coronal surface of the cortical bone. In addition, higher stress intensity in the bone tissue in contact with implant surface was observed.

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Table 1. Description of models used in the study.

	Loading Type	Occlusal Splint Interposition	Implant Insertion Depth	Implant Dimensions	Abutment Gingival Height	Number of Elements
Model 1	Normal	No	Bone Level	4.0 x 11-mm	1.5 mm	604 000
Model 2	Normal	No	2-mm Subcrestal	4.0 x 9-mm	3.5 mm	688 238
Model 3	Normal	Yes	Bone Level	4.0 x 11-mm	1.5 mm	556 597
Model 4	Normal	Yes	2-mm Subcrestal	4.0 x 9-mm	3.5 mm	488 692
Model 5	Parafunctional	No	Bone Level	4.0 x 11-mm	1.5 mm	604 000
Model 6	Parafunctional	No	2-mm Subcrestal	4.0 x 9-mm	3.5 mm	688 238
Model 7	Parafunctional	Yes	Bone Level	4.0 x 11-mm	1.5 mm	556 597
Model 8	Parafunctional	Yes	2-mm Subcrestal	4.0 x 9-mm	3.5 mm	488 692

Table 2. Properties of materials modeled.

Material	Elastic Modulus (GPa)	Poisson's Ratio	Reference
Cortical Bone	13.70	0.30	Abu-Hammad et al[30]
Trabecular Bone	1.37	0.28	Abu-Hammad et al[30]
Titanium (Implant)	110.00	0.33	Korioth & Johann[31]
Titanium (Abutment)	110.00	0.28	Sakaguchi & Borgersen[32]
Enamel	80.00	0.30	Rees & Jacobsen[33]
Dentin	15.00	0.31	Rees & Jacobsen[33]
Periodontal Ligament	0.05	0.49	Rees & Jacobsen[34]
Acrylic Resin	2.40	0.35	Stegaroiu et al[35]
Ni-Cr Alloy	206.00	0.33	Anusavice & Hojjatie[36]
Feldspatic Porcelain	82.80	0.35	Papavasiliou et al[37]

FIGURES

Figure 1. Three-dimensional computer-aided design models. A, Mandibular structures with 4 x 11 mm implant inserted at bone level position. B, Mandibular structures with 4 x 9 mm implant inserted 2-mm subcrestally. C, Natural teeth as antagonist. D, Acrylic resin splint as antagonist

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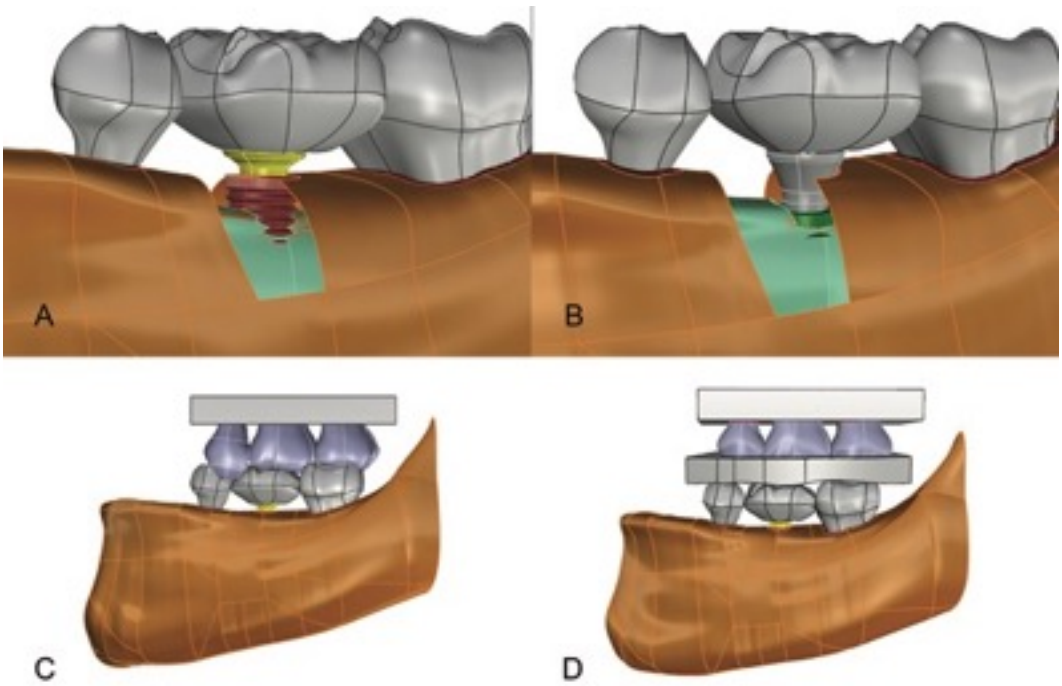


Figure 2. Computer-aided design models of implants and abutments. A, 4 x 11 mm implant, and 4.5 x 4 x 1.5 mm abutment. B, 4 x 9 mm implant, and 4.5 x 4 x 3.5 mm abutment. The lower letters indicate: a, abutment; b, implant; c, assembled model; d, assembled section view.

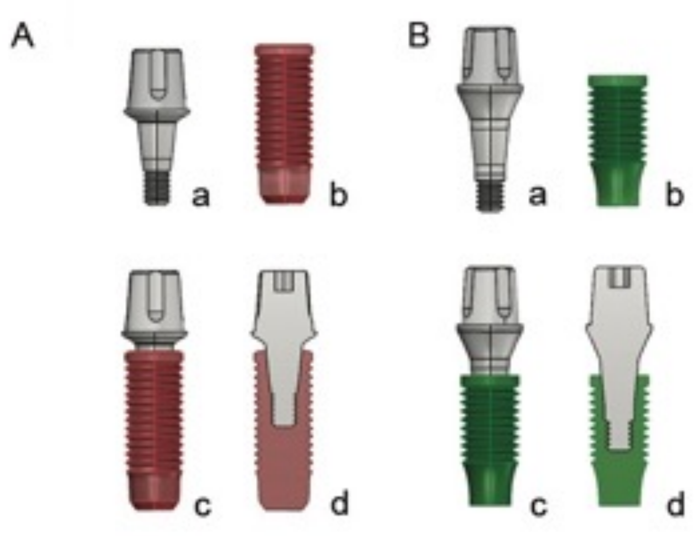
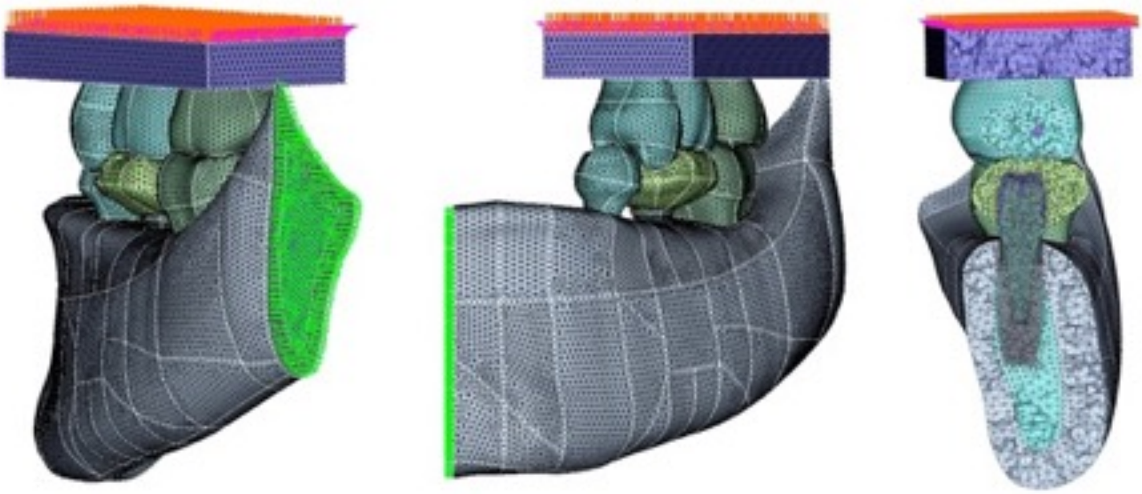


Figure 3. Finite element models. A, Fixed constraints (green) at distal surface. B, Symmetrical constraints (green) at mesial surface. C, Unrestricted constraints with loading conditions (orange and pink) on top surface of solid block.



A B C

Figure 4. Maximum principal stress distribution in the periimplant bone at frontal plane. Lingual side to the left. A, Model 1. B, Model 3. C, Model 2. D, Model 4. E, Model 5. F, Model 7. G, Model 6. H, Model 8. Natural teeth and occlusal splint as antagonist material in the left and right columns, respectively.

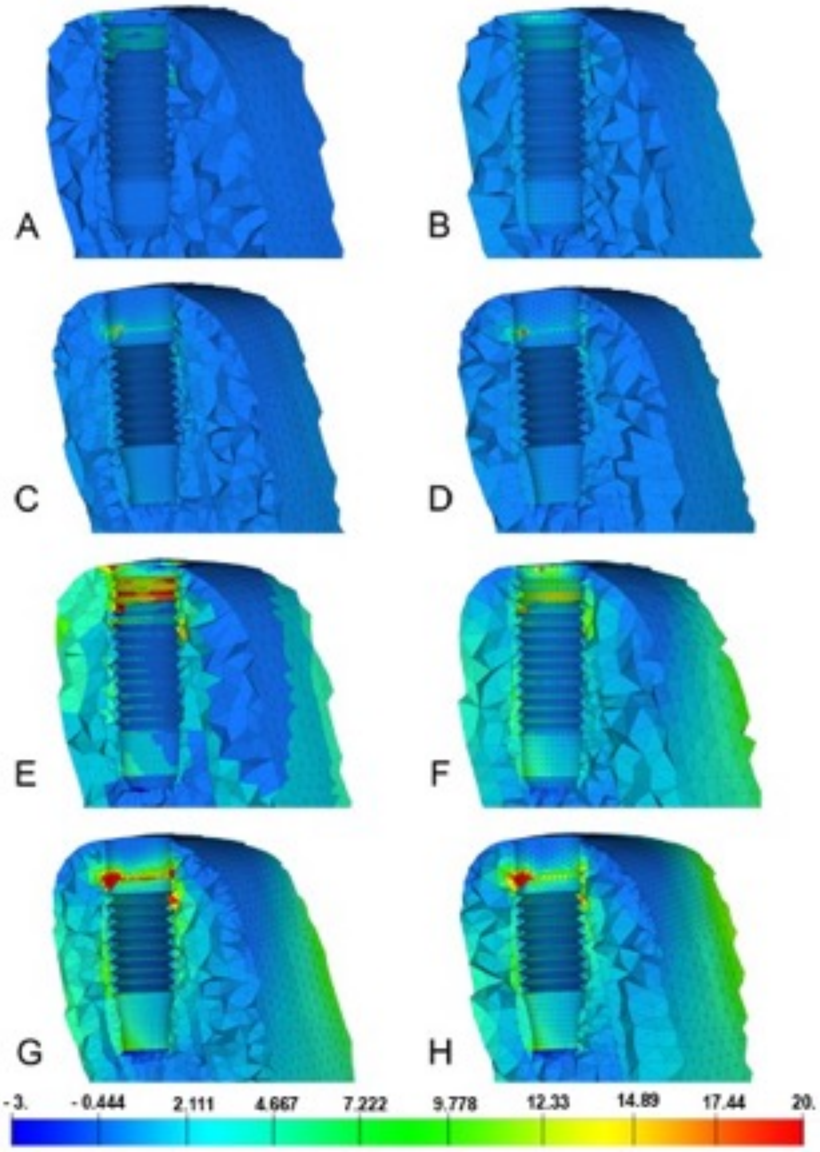


Figure 5. von Mises stress distribution in prosthetic abutments. Buccal side to the right. A, Model 1. B, Model 3. C, Model 2. D, Model 4. E, Model 5. F, Model 7. G, Model 6. H, Model 8. Natural teeth and occlusal splint as antagonist materials in the left and right columns, respectively.

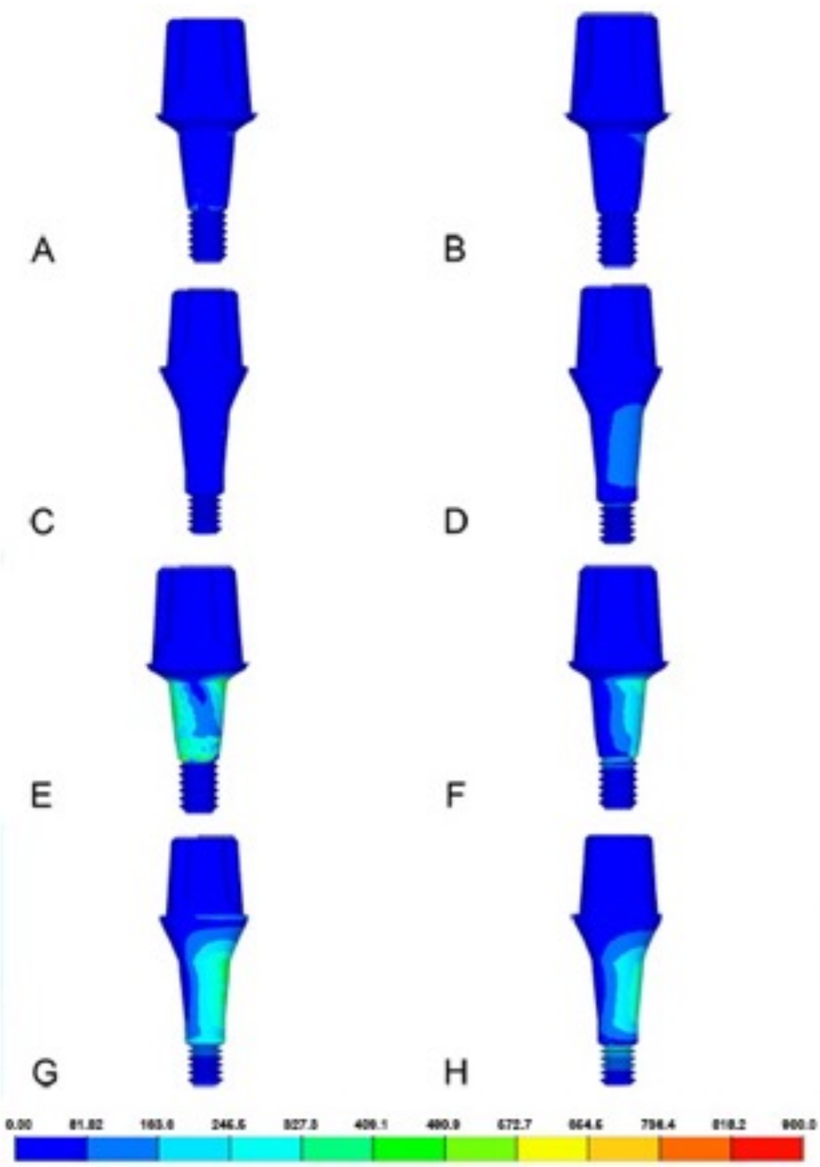
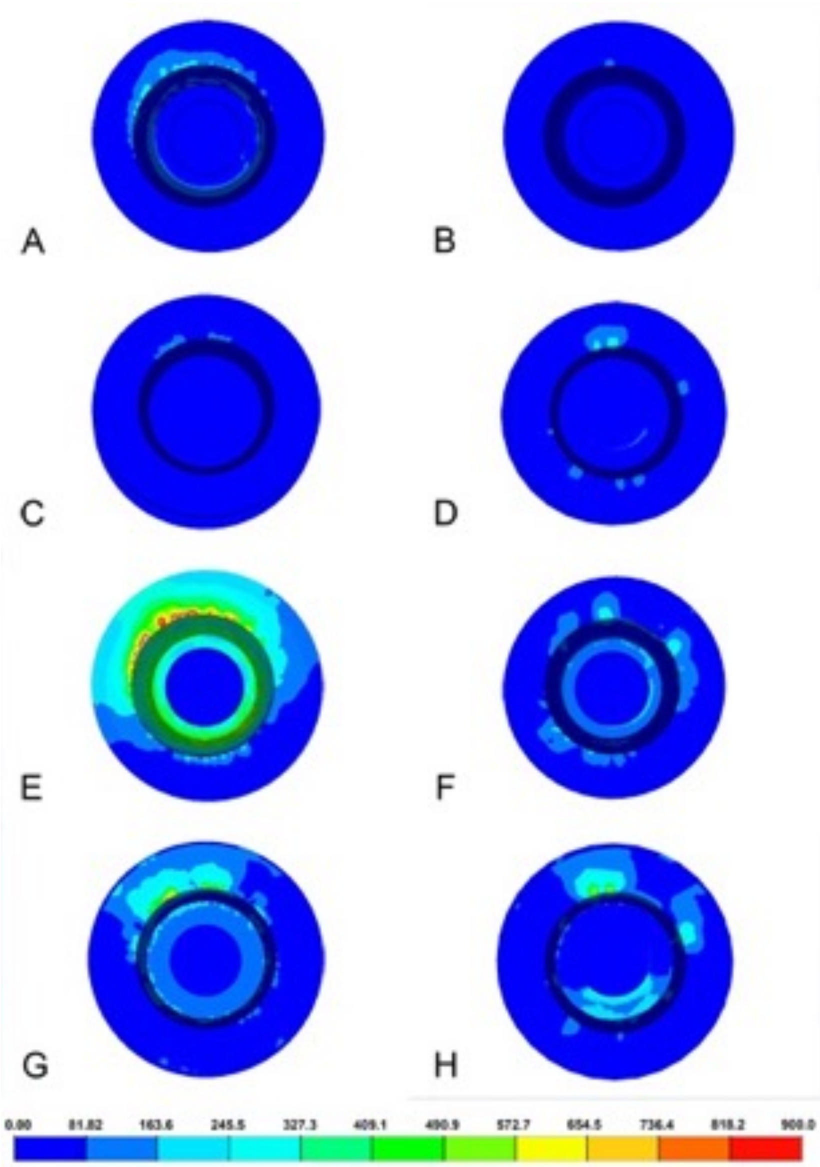


Figure 6. von Mises stress distribution in implants. Buccal side to the bottom. A, Model 1. B, Model 3. C, Model 2. D, Model 4. E, Model 5. F, Model 7. G, Model 6. H, Model 8. Natural teeth and occlusal splint as antagonist material in the left and right columns, respectively.



3 Capítulo 2[2]

Prediction of marginal bone loss around dental implants: 12-months follow-up.

Abbreviated title: Marginal bone loss around dental implants.

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The authors do not have any financial interests, either directly or indirectly, in the products or information listed in the paper.

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ABSTRACT

Background: Few studies predicting the clustered effect of the implant, peri-implant, and occlusal variables on marginal bone loss (MBL).

Purpose: To evaluate 12-months prospective data predicting risk factors for MBL in dental implants.

Material and Methods: Participants (n=33) received 109 cone morse implants (width: 3.5 to 5mm, length: 6 to 15mm). Implants were radiographically examined at the day of surgery (baseline) and 12 months after prosthesis loading; and clinically at 1 month and 12 months after prosthesis loading. Implant, peri-implant, and occlusal-related independent variables were analyzed by decision tree analysis using the classification and regression tree and Chi-squared automatic interaction detection. Two-levels multilevel mixed effect analysis was used to estimate predictive values of each analytical model (α= 0.05).

Results: Predictive model revealed higher MBL at mesial (mean of 0.87 mm; ranged from 0.5 to 1.19) than distal sites (mean of 0.73 mm; ranged from 0.4 to 1.12 mm). Highest level of MBL was found in association with cement-retained prosthesis, platform diameter of 3.5mm, papilla sizes up to 2mm, keratinized gingival width inferior to 3mm, implant lengths above 8.5mm, inadequate occlusal schemes, presence of bleeding on probing and deeper pocket.

Conclusions: Platform diameter of 3.5mm and cemented prostheses were the main variables in association with MBL. However, they only matter when in association with other peri-implant and occlusal-related variables. Among these, keratinized gingival height inferior to 3mm and inadequate occlusal schemes appeared more frequently.

1 INTRODUCTION

Stability of peri-implant bone levels can be obtained by understanding tissue healing, which has been related with implant characteristics, position and care during installation.[1] Comprehend the factors associated with peri-implant tissue remodeling is crucial to increase the prediction of implant stability and, thus its longevity. The most cited factors comprise implant handling and surgical trauma, biological width and biofilm, and relationship between implant and abutment.[2,3] A more pronounced marginal bone loss (MBL) in the first year after implant rehabilitation is a common finding. Studies have shown an annual rate of subsequent MBL around the implant neck of 0.2 mm after the first year.[4]

Even though different factors have been pointed as potential predictors of MBL per se, there is lack of consensus within literature regarding the role played by each pointed factor. Concerning peri-implant factors, for example, the influence of keratinized mucosa width around implants has been poorly studied in prospective clinical studies and it is still under debate, because implant stability can be maintained even with lack of keratinized mucosa.[5,6] In fact, it seems that peri-implant characteristics by themselves cannot cause progressive bone reabsorption; nonetheless, overloading associated with reduced peri-implant soft tissues could result in MBL and early implant failure.[7]

Although some studies concerning peri-implant complications have been reported,[8-13] there is still a lack of clinical investigations to identify predictive factors for bone loss. Most of the studies use statistical models for causal explanation, i.e. including only previously well-stablished risk factors, a comprehensive misunderstanding between predicting and explaining. [14] The use of prediction techniques provides the opportunity to test new theories and to discover new causal mechanisms and relations among variables alongside explanatory modeling. [14] A better understanding of the predictive factors associated with different degrees of MBL may provide data for the planning of future studies, facilitate clinical decision-making, and may enhance implant success rates.

Given the aforementioned, this prospective clinical study investigated possible predictive risk factors for MBL in proximal surfaces of dental implants after the first year of implant loading. It was hypothesized that different levels of MBL could be influenced by different implant, peri-implant and occlusal-related characteristics.

2 MATERIALS AND METHODS

2.1 Study Design/ Patient selection

This observational longitudinal study was approved by the Local Ethics Committee (CAAE 34042214.2.0000.5319, CNS protocol nº 196/1996) and followed the STROBE guidelines for reporting observational study.[15] This study was conducted in a university setting from March 2015 to December 2016. All individuals who needed implant-prosthetic rehabilitation and reported to be systemically healthy were invited to participate in the study and signed an informed consent. Exclusion criteria comprised uncontrolled diabetes and prior therapeutic radiation of the jaws.

Subjects included were treated by properly trained clinicians and received cone morse implants (Neodent, Curitiba, PR, BRAZIL; or PI-Brånemark, Zimmer Biomet, Miami, FL, USA), width between 3.5 and 5 mm and length between 6 and 15 mm according to a previous treatment plan. A healing period with implant submersion for three or six months was allowed before prosthetic loading for the lower and upper arch, respectively. Implants were radiographically examined at the day of the surgery (baseline) and 12 months after prosthesis loading by one calibrated examiner; and clinically at 1 month and 12 months after prosthesis loading by a second examiner.

2.2 Independent variables

(a) Periodontal evaluation: (i) Plaque index: presence of visible plaque;[16] *(ii) Pocket depth:* measured from the margin to the bottom of the pocket;[16] *(iii) Bleeding on probing (BOP):* presence of bleeding up to 15 seconds after probing;[16] *(iv) Keratinized tissue width:* measured in millimeter from the gingival margin to the mucogingival junction;[17] *(v) Papilla height:* assessed from the tip of the papilla to the connecting line of the two neighboring gingival zeniths.[18] All measurements were performed at distal, buccal, mesial, and palatal/lingual surfaces using a Williams 23 probe (Hu−Friedy, Chicago, IL, USA) when indicated.

(b) Prosthetic retention: cemented or screwed crowns.

(c) Arch variables: (i) bone graft: presence or absence; *(ii) location:* anterior or posterior; maxilla or mandible.

(d) Occlusion variables: (i) Anterior guidance: adequate, when the mandible moves into a protrusive position and there are adequate implant and tooth−guided contacts on the anterior teeth to disocclude all posterior teeth immediately; or *inadequate; (ii) Lateral guidance: group guidance*, when the mandible moves forward into lateral position, and there are implant and tooth−guided contacts; or *canine guidance,* there are implant or tooth−guided contacts involving only tooth or implant;

(e) Occlusal contacts: inadequate, a dark occlusal mark is an occlusal contact or premature contact (high spot); or *adequate,* a light occlusal mark is not necessarily an occlusal contact. The contacts between upper and lower teeth in static and dynamics movements were obtained through articulating paper (Bausch Progress 100 micron, Bausch Lomb Incorporated, United Kingdom, England) and visually checked.

2.3 Outcome variable

For MBL assessment standardized intra−oral periapical radiographs were taken at implant placement (baseline) and re−examination after 12 months of prosthetic loading. All radiographs were taken using the long−cone paralleling technique and a plastic X−ray holder (Kodak E-speed film, Eastman Kodak Co., Rochester, NY, USA) with a standardized exposure time of 0.8 seconds. The images were photographed in a perpendicular incidence against a negatoscope with a digital camera (Canon Rebel T5i DSLR and Canon EF 100mm f/2.8 Macro USM Lens, Canon Inc., Tokyo, Japan) for the digital measurements (ImageJ, National Institutes of Health, Bethesda, MD, USA). In order to avoid misinterpretation, all images were viewed on the same monitor (MacBook Pro, Apple Inc., Cupertino, CA, USA), in a dimly lit room, under the same conditions, by one calibrated examiner. Radiographic MBL measurements in random implants were repeated until the examiner presented high intra-examiner reliability as measured by Cohen's Kappa (K = 0.89). A computer−assisted calibration was performed for each radiograph by scale setting assisted by the known implant diameter and length data, providing an increase in the reliability and the precision for the radiographic measurements. The peri-implant bone level was measured in millimeters (mm) from the shoulder of the implant platform to the most coronal aspect of the alveolar crest at mesial and distal sites.[16] Each measurement was repeated three times with an interval of one week and the mean was calculated. The MBL was calculated as the difference between the initial bone level (baseline) and the bone level at the re−examination after 12 months of prosthetic loading.

2.4 Statistical Analysis

Descriptive statistics using the mean, standard deviation, and frequency was applied. Independent variables were analyzed by using decision tree analysis (DTA) with the classification and regression tree (CART) and Chi-squared automatic interaction detection (CHAID) approaches.[14] DTA analyses were conducted in SPSS 24.0 (IBM Corp., NY, USA). Outcome variables were then dichotomized for the ease of data interpretation. Bone losses were dichotomized as above or below the mean. Also, they were grouped into tertiles of the observed bone loss distribution. The upper tertile comprised the most extreme bone losses as positive cases. Bone losses in the lower tertile represented the lowest values observed. Variables associated with the outcomes in the first three levels of DTA were included in a mixed-effects two-levels multivariable multilevel model. Predictive values of outcome occurrence considering the simultaneous combination of the independent variables were estimated after the fit of the multilevel models. Multilevel analyses were conducted in StataSE 14.1 (StataCorp, TX, USA).

3 RESULTS

Thirty three patients (64% women and 36% men), with a mean age of 53±10 years (ranged from 32 to 69 years old), were enrolled in this study and received 109 cone morse implants (Neodent, Curitiba, PR, BRAZIL; or PI-Brånemark, Zimmer Biomet, Miami, FL, USA) in the anterior (28%) and posterior area (72%). Significant higher MBL at mesial (mean of 0.87mm; ranged from 0.5 to 1.19mm) was observed in comparison with distal sites (mean of 0.73mm; ranged from 0.4 to 1.12mm).

Three included subjects reported diabetes but all were controlled with medicaments as shown in blood samples, and only two reported being a current smoker (no more than 10 cigarettes per day). None of the participants reported to have been diagnosed and treated for periodontal disease before the implant placement. From the total of 109 implants placed, none was lost in 12-months follow-up, resulting in an implant survival rate of 100%. All prosthetic constructions were in function until the end of assessment, showing 100% success rate. Despite this, prosthetic complications were present and the most common were prosthetic screw loosening (n=8), loss of the access hole restoration (n=3) and antagonist material fracture (n=2). These complications were immediately solved when reported by the participants.

3.1 Mesial sites

Multivariable models for MBL mean values in the upper and lower tertiles at mesial sites are showed respectively in the Table 1 and 2. The highest levels of MBL were associated with cement-retained prosthesis (P=0.003) or with platform diameter inferior to 3.5 mm (P=0.022) (Figure 1; Supplementary material). Regardless of the type of prosthesis retention, screwed or cemented, the use of platforms of 3.5mm presented higher prevalence of MBL (P=0.049 and P=0.046) (Figure 1A; Supplementary material). Considering the combination of these variables in a mesial site, maximum predictive value was 89.8%. Analyzing data on the platform perspective (Figure 1B; Supplementary material), MBL in platforms below 3.5mm was associated with keratinized gingival height of less than 3mm (P=0.019). Even though wearing platforms above 3.5mm was protective for MBL, an increased prevalence of MBL was observed when these platforms were associated with cement-retained prosthesis (P=0.040), especially in males (P=0.024). The maximum predictive level was 91.2%.

Sites within the lowest tertile (Figure 2, Supplementary material) lost up to 0.5 mm in the first year, which were associated with presence of cement-retained prosthesis (P=0.017). The few cases observed in the group that received screw-retained prosthesis were mostly associated with platform sizes bellow 3.8mm (P=0.017). Papilla sizes up to 2.2 mm were more associated with MBL among individuals with cemented prosthesis (P=0.010). The association of these variables resulted in a maximum predictive value of 83.7%.

Among the individuals within the upper tertile (Figure 3; Supplementary material), which lost more than 1.19 mm in the first year, the prosthetic retention and size of platform factors were associated in the first level, i.e., they were more relevant to the problem. Cemented prosthesis presented a higher prevalence of MBL (P=0.028), which was associated with presence of BOP (P=0.028) in the second level and inadequate canine guidance in the lower level (P=0.047) (Figure 3A; Supplementary material). The combination of these variables presented a maximum predictive value of 77.3% of the sites. Regarding the platform size, diameters above 3.75 were protective for MBL (P=0.049) and losses observed were associated with increased pocket depths (P=0.012). In pocket depths 3mm or higher MBL were associated with inadequate occlusal contact (P=0.030), in shallow pockets bone losses were associated with gingival papilla sizes below 1.2mm (P=0.014). When platforms of 3.5mm in diameter were used, inadequate occlusal contact was associated with a higher prevalence of MBL (P=0.003) (Figure 3B; Supplementary material). Predictive values considering the platform model were 76.5%.

3.2 Distal sites

Multivariable models for MBL mean values in the upper and lower tertiles of MBL at distal sites are shown respectively in Table 3 and 4. In the first level (Figure 4; Supplementary material), papilla height above 2 mm (P=0.049) or wearing platform above 3.8 mm (P=0.014) were protective for MBL. Among those with papilla heights above 2 mm, bone losses were associated with pocket depths above 3 mm (P=0.019) in the second level and implant length above 9mm in a third level (P=0.026). In sites with papilla heights up to 2mm, losses were associated with cement-retained prosthesis (P=0.010) and presence of BOP (P=0.040) (Figure

4A; Supplementary material). Platforms up to 3.8mm presented greater MBL especially when associated with implant lengths superior to 7mm (P=0.024) in areas with less than 2mm of papilla height (P=0.017). Even though wearing platforms above 3.8mm were protective, bone losses above the mean were associated with inadequate anterior guidance (P=0.016) and in the third level, with BOP (P=0.018) among those with adequate anterior guidance (Figure 4B; Supplementary material). Maximum predictive values for MBL were 96.1% and 94.7% considering the papilla height and the platform diameter models, respectively.

Individuals within the lowest tertile lost up to 0.4 mm in the first year, which were associated with presence of papilla of at least 2mm (P=0.011) and screw-retained prosthesis (P=0.010). Bone losses in sites with papilla height below 2mm were associated with platform diameters inferior to 4.3mm (P=0.050). In sites with papilla heights above 2mm, MBL were associated with implant lengths above 8.5mm (P=0.022). Prediction of MBL reached 93.1% with this model. Regarding prosthesis, in screw-retained prosthesis, papilla heights inferior to 3mm were associated with higher proportion of MBL (P=0.025). In cement-retained prosthesis the most important factor was the use of implants longer than 8.5mm (P=0.040), in special when associated with papilla heights inferior to 2.2 mm (P=0.027) (Figure 5; Supplementary material). MBL predictive value was 95.0%.

Among the individuals within the upper tertile (Figure 6; Supplementary material), which lost more than 1.12 mm in the first year, the papilla size (P=0.031) and prosthetic retention (P=0.004) were associated in the first level. A papilla size of at least 3.1mm presented a protective role for bone loss, as well as wearing a screw-retained prosthesis. Among those with papilla size of up to 3.1 mm, a platform diameter of less than 3.8mm (P=0.028), especially associated with absence of papilla determined bone losses (P=0.023) (Figure 6A; Supplementary material). Even though screw-retained prostheses were less associated with high levels of bone loss, positive cases were more prevalent when platforms had 3.5mm in diameter (P=0.014). In the case of cemented prosthesis, papilla heights bellow 3.1mm were more likely to present bone loss (P=0.043), in special when associated with inadequate occlusal contact (P=0.018) (Figure 6B; Supplementary material). Considering the papilla height or the type of prosthesis model, prediction of MBL was 91.2% and 80.5% respectively.

4 DISCUSSION

This study explored possible predictive risk factors for MBL after the first year of installation through decision-tree analysis and multilevel models. Our hypothesis was accepted since MBL was significantly influenced by different implant, peri-implant and occlusal-related characteristics. Overall, highest level of MBL was found in association with cement-retained prosthesis, platform diameter of 3.5mm, papilla sizes up to 2mm, keratinized gingival height inferior to 3mm, implant lengths above 8.5mm, inadequate occlusal schemes, presence of BOP and deeper pockets. Except for the papilla size, peri-implant and occlusal-related characteristics were more observed in the second and third level; while implant-related factors as platform diameters and prosthetic retention type were associated to first level of our analytical models.

Regarding implant-related characteristics, our findings showed increased prevalence of MBL among individuals with cement-retained prosthesis. The observed higher MBL for cemented compared to screw-retained implant supported restorations have been previously described,[9,19] but there is still controversy in literature.[10] Differences may be attributed to subgingival remaining of cement yielding inflammation and reabsorption of marginal peri-implant bone.[11] In addition, the gap formation during cementation, and the microleakage originated due to relative solubility of the luting material could result in biofilm formation at crown-implant interface.[19] Another disadvantage is that standard abutments for cemented restoration are usually too narrow to support the entire restoration without leaving undercuts, which are very difficult to reach during cleaning.[12] Finally, it seems that the type of prosthetic retention had a decisive role in the risk of developing biologic complications.[8]

Concerning platform diameter, narrow implants (< 3.3mm) might present significantly lower survival rates than wider implants (> 3.3mm).[2] Conversely, a randomized clinical study did not find increased MBL with smaller diameter implants.[20] Currently, few studies evaluated the MBL as the outcome of direct comparisons. Unlike the reports in the literature,[20-23] the evidence of our study suggests that wearing a small platform diameter was a predictive factor for MBL. The difference in diameter size between our study and the previous ones might be a reasonable explanation for our divergent findings.[21,23] Other possible explanation is that in our study the abutments presented equal diameters, regardless of the width of the implants. Previous studies reported that increasing discrepancy between the diameter of the platform and the restorative abutment could decrease the amount of subsequent MBL.[20,22,24,25] The increase of implant diameter reduces the stress around implant and the negative impact of implant/abutment microgaps.[20,21,25] Further studies could be helpful to clarify the relevance of implant diameters rather than platform switching in preserving marginal bone.

Isolated implant-related characteristics failed to explain MBL. Even though implant-related variables appeared more frequently associated with MBL in the first level of the decision tree analysis, peri-implant and occlusal-related factors also influenced MBL. In fact, occlusal interferences and trauma have also been linked to etiology of peri-implantitis and MBL.[26-28] Our findings suggest that, even when implant-prosthetic characteristics play a protective role, e.g. the use of screw- instead of cement-retained prosthesis, higher MBL were observed under inappropriate occlusal patterns, such as inadequate anterior and canine guidance or inadequate occlusal contacts. These findings are in agreement with previous clinical study,[29] which reported significant differences in the MBL around implants of individuals with inadequate anterior guidance, non-working side contacts and lateral group function involving teeth and implants. Due to the lack of periodontal mechanoreceptor feedback, the control of the muscles of mastication is reduced and does not decrease the load applied to implant-supported restorations, resulting in greater stress on peri-implantar crestal bone.[30] Thus, dental implants are less able to withstand traumatic occlusal forces being more vulnerable to non-axial forces compared to teeth.[31]

Moreover, higher MBL in platform diameter of 3.5 mm was associated with keratinized gingival width of less than 3mm. These results are in line with previous studies, which have reported that thinner soft tissue is more likely to develop bone loss around implant.[32,33] Thus, soft tissue thickness should be considered a primordial factor to reduce MBL.[33-35] In contrast, other investigators reported no association between keratinized mucosa width and MBL around dental implants.[36-38] Chung et al. (2006) assessed the influence of the keratinized gingival width in a retrospective design and the information on mucosa widths prior to implant placement was absent. Still, according to Canullo et al. (2017) their study failed to prove the influence of keratinized mucosa on MBL due to the small sample size or due to no further influence of keratinized mucosa on MBL after 3 years of implant healing. The different designs and lack of important variables could be a confounding factor for the interpretation of results.

One of the strengths of this study was the analytical approach employed. We were able to select potential variables influencing MBL by decision trees analysis, which could prevent the empirical inclusion of variables in the multivariable models. Also, the multilevel approach used for estimating predictive values provided robust information considering two different levels: implants and individuals. One may speculate the need of a third level; however, preliminary analyses have shown the absence of a third level effect (data not shown). Furthermore, the MBL was evaluated at mesial and distal sites independently, avoiding the use of the mean values, which could originate bias and misenterpretation.[38] Our study is not free of limitations, as standardized periapical radiographs only provide information about mesial and distal bone levels, the buccal and lingual bone levels were not evaluated in our study. However, this limitation applies to all studies of this kind.[45,46]

MBL development and progression in order to explore causality has been challenging. Further predictive models for long−term prospective clinical should be performed to better understand the predictive factors of peri-implant and occlusal parameters on later MBL. An important first step with our study is to show that MBL is multifactorial and influenced by a combination of implant, peri-implant and occlusal-related factors. Given the short follow-up of this study, the low cumulative effect could explain a reduced influence of peri-implant and occlusal factors on MBL. It is important to highlight that an accurate estimation of the prevalence of MBL from large number of individuals evaluated during long-time in prospective clinical trials is also necessary to identify the strength of association between exposure and outcome.

5 CONCLUSIONS

Platform diameter of 3.5mm and cemented prostheses were the main variables in association with MBL. However, they only matter when in association with other peri-implant and occlusal-related variables. Among these, keratinized gingival height inferior to 3mm and inadequate occlusal schemes appeared more frequently.

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Table 1. Variables included in each multivariable model for mesial bone loss, logistic regression coefficients and 95% Confidence Interval (95% CI).

Variables included in the model	Coefficient	95% CI
Mean value		
1st level variable: Type of prosthesis		
Type of prosthesis	0.20	0.07-0.64
Platform (3.5 mm)	0.24	0.07-0.88
Predictive value mean (range)	0.52 (0.11-0.90)	
Mean value		
1st level variable: Platform (3.5 mm)		
Platform (3.5 mm)	0.22	0.07-0.76
Type of prosthesis	0.18	0.06-.061
Keratinized gingiva (3.0 mm)	1.47	0.58-3.70
Gender	0.55	0.23-1.31
Predictive value mean (range)	0.56 (0.10-0.91)	
Upper tertile		
1st level variable: Prosthesis		
Type of prosthesis	0.23	0.07-0.81
Bleeding on probing	0.47	0.19-1.17
Canine guidance	0.72	0.14-3.60
Platform (3.5 mm)	0.27	0.08-0.90
Predictive value mean (range)	0.32 (0.05-0.77)	
Upper tertile		
1st level variable: Platform (3.5 mm)		
Platform (3.5 mm)	0.29	0.10-0.85
Pocket depth (2.0 mm)	0.33	0.14-0.80
Occlusion	1.65	0.64-4.28
Papilla (1.2 mm)	0.60	0.23-1.55
Predictive value mean (range)	0.36 (0.16-0.77)	

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Table 2. Variables included in each multivariable model for mesial bone loss at the lower tertile, logistic regression coefficients and 95% Confidence Interval (95% CI).

Variables included in the model	Coefficient	95% CI
Lower tertile		
1st level variable: Type of prosthesis		
Type of prosthesis	0.42	0.16-1.11
Papilla (2.2 mm)	0.53	0.22-1.29
Platform (3.75 mm)	0.78	0.34-1.83
Predictive value mean (range)	0.69 (0.42-0.84)	

Table 3. Variables included in each multivariable model for distal bone loss, logistic regression coefficients and 95% Confidence Interval (95% CI).

Variables included in the model	Coefficient	95% CI
Mean value		
1st level variable: Papilla (2.0 mm)		
Papilla (2.0 mm)	0.35	0.12-0.99
Type of prosthesis	0.53	0.15-1.81
Pocket depth (3.0 mm)	2.38	0.35-16.23
Bleeding on probing	1.87	0.68-5.16
Implant length (9.0 mm)	2.61	0.99-6.90
Predictive value mean (range)	0.49 (0.14-0.96)	
Mean value		
1st level variable: Platform (3.8 mm)		
Platform (3.8 mm)	0.33	0.11-1.01
Implant length (7.0 mm)	1.07	0.28-4.09
Anterior guidance	2.46	0.50-12.15
Papilla (2.0 mm)	0.36	0.12-1.08
Bleeding on probing	1.67	0.56-4.97
Predictive value mean (range)	0.50 (0.12-0.95)	
Upper tertile		
1st level variable: Papilla (3.1 mm)		
Papilla (3.1 mm)	0.30	0.09-1.02
Platform (3.8 mm)	0.32	0.11-0.90
Papilla (absence)	0.27	0.07-1.13
Predictive value mean (range)	0.29 (0.05-0.91)	
Upper tertile		

1st level variable: Type of prosthesis		
Type of prosthesis	0.64	0.17-2.38
Papilla (3.1 mm)	0.32	0.10-1.04
Pocket depth (2.0 mm)	2.60	0.39-17.30
Occlusion	2.36	0.76-7.29
Keratinized gingiva (2.0 mm)	0.84	0.28-2.52
Papilla (3.0 mm)	0.27	0.08-0.90
Predictive value mean (range)	0.29 (0.05-0.81)	

Table 4. Variables included in each multivariable model for distal bone loss at the lower tertile, logistic regression coefficients and 95% Confidence Interval (95% CI).

Variables included in the model	**Coeffici-ent**	**95% CI**
Lower tertile		
1st level variable: Type of prosthesis		
Type of prosthesis	0.41	0.12-1.42
Implant length (8.5 mm)	4.54	1.51-13.67
Papilla (3.0 mm)	1.66	0.45-6.14
Papilla (2.2 mm)	0.29	0.08-1.06
Predictive value mean (range)	0.66 (0.17-0.95)	
Lower tertile		
1st level variable: Papilla (2.0 mm)		
Papilla (2.0 mm)	0.32	0.11-0.96
Platform (4.3 mm)	0.50	0.15-1.60
Implant length (8.5 mm)	3.14	1.04-9.46
Predictive value mean (range)	0.67 (0.14-0.93)	

SUPPLEMENTARY MATERIAL

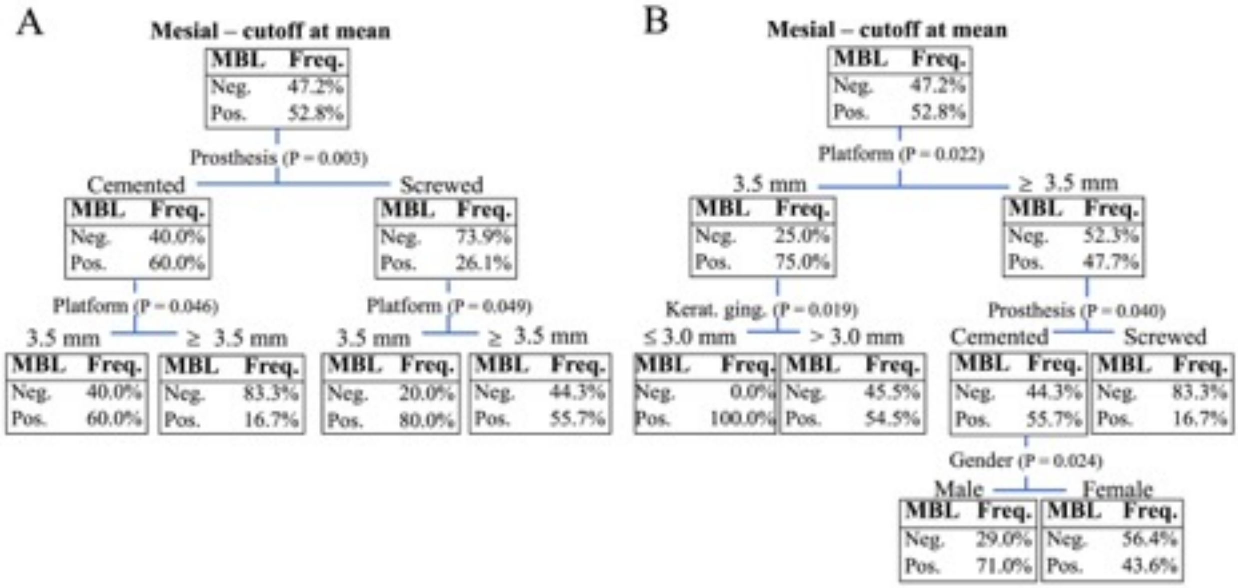

Figure 1. Mean MBL frequencies at mesial sites related to prosthetic retention (A); and platform diameter (B).

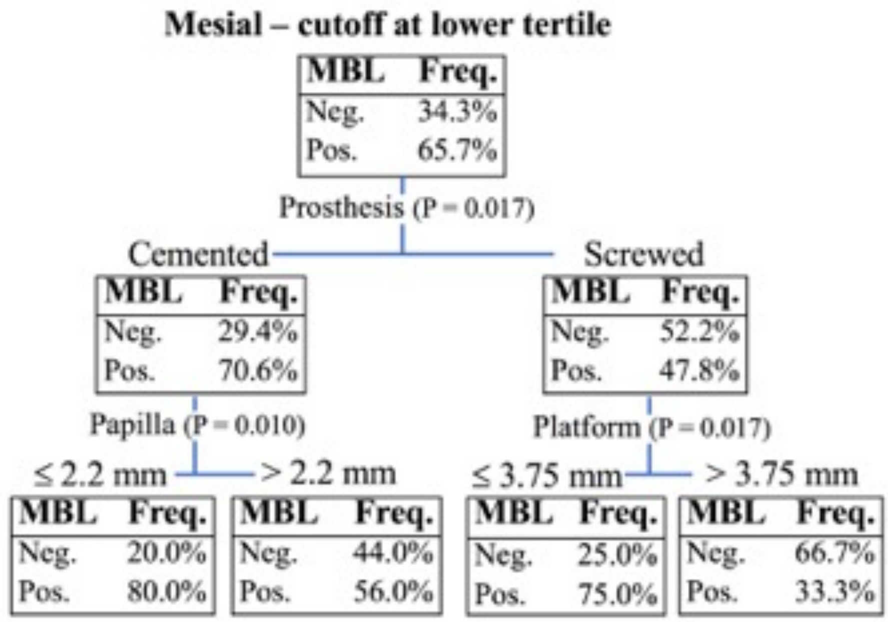

Figure 2. Lower tertile of MBL at mesial sites.

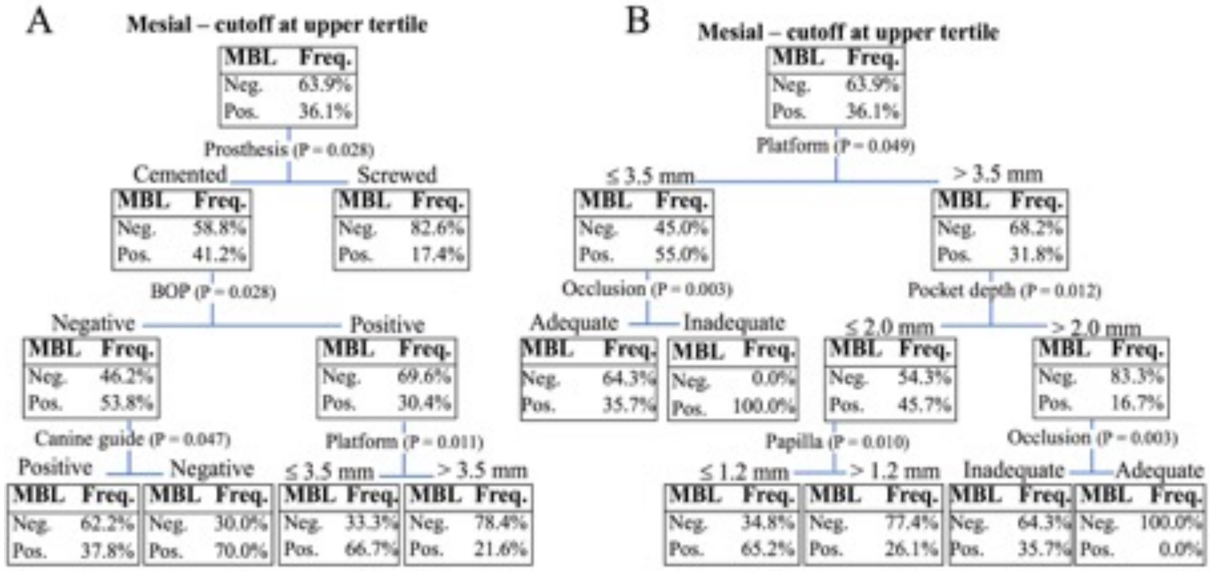

Figure 3. Upper tertile of MBL at mesial sites related to prosthetic retention (A); and platform diameter (B).

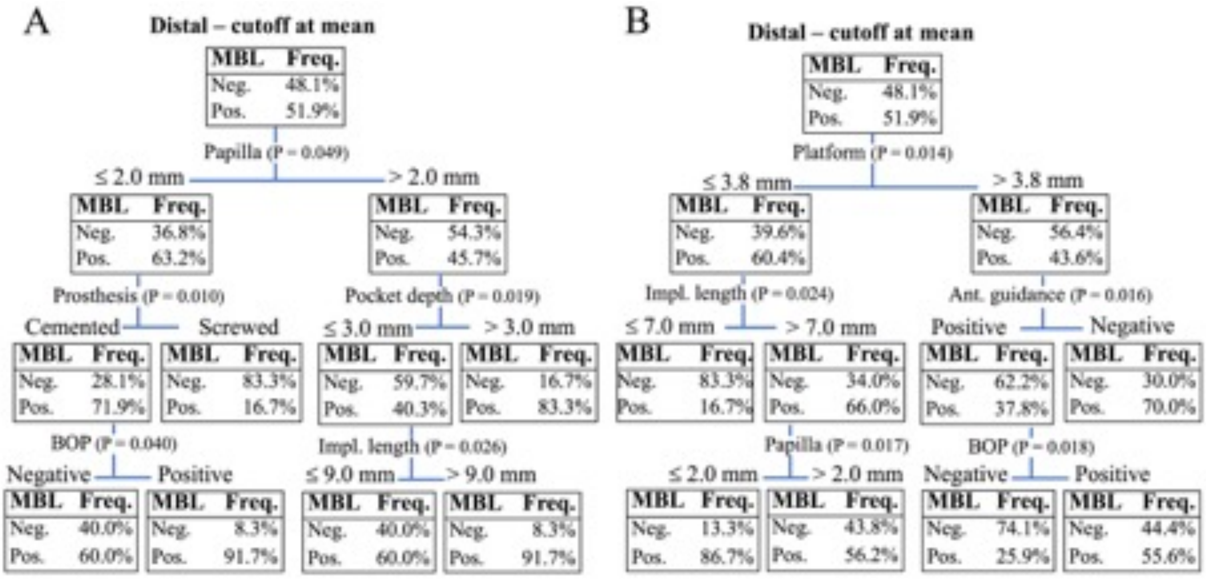

Figure 4. Mean MBL frequencies at distal sites related to papilla height (A); and platform diameter (B).

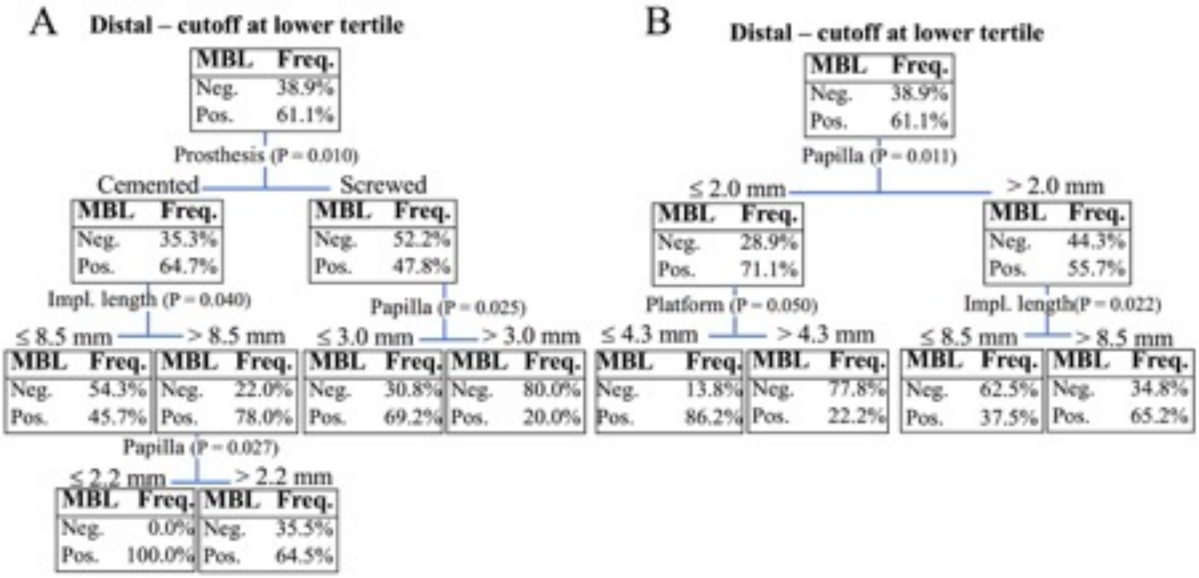

Figure 5. Lower tertile of MBL at distal sites related to prosthetic retention (A); and papilla height (B).

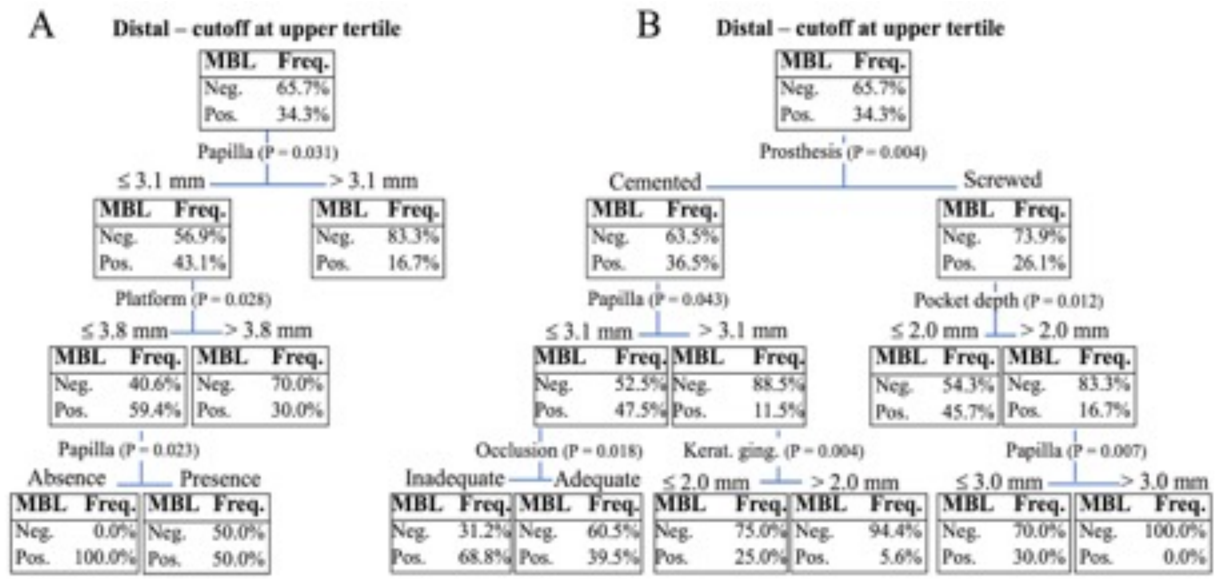

Figure 6. Upper tertile of MBL at distal sites related to papilla height (A); and prosthetic retention (B).

4 Considerações Finais

Este estudo avaliou fatores relacionados às tensões e à perda óssea ao redor do implante. A AEF demonstrou que forças oclusais parafuncionais aumentam consideravelmente o nível de concentração de tensões nos tecidos ósseos peri-implantares e no conjunto implante-prótese. Porém, o uso de placa oclusal de resina acrílica reduziu a intensidade destas tensões, podendo ter seu uso indicado com a finaldade de proteger os componentes protéticos, implantes e tecidos ósseos peri-implantares das sobrecargas oclusais. Ainda foi observado que caso ocorram limitações anatômicas que levem o cirurgião a optar entre posicionar a plataforma de um implante mais curto a 2 mm infra-ósseos ou instalar um implante mais comprido mantendo a plataforma no mesmo nível da crista óssea, seria mais indicada a primeira situação. Pois a instalação infra-óssea apresentou menores concentrações de tensão no conjunto implante-prótese e na crista óssea cortical quando comparada a um implante mais longo instalado no mesmo nível da crista óssea. Como a instalação do implante com a plataforma situada 2 mm infra-ósseo pode posicionar o mesmo praticamente apenas em osso medular, observou-se que a superfície do tecido ósseo trabecular em contato com o implante demonstrou maior concentração de tensões comparando-se com a situação do implante mais comprido instalado no mesmo nível da crista óssea. Assim, a atenção deve ser redobrada no caso de cirurgias que visem provisionalização imediata, pois esta maior concentração de tensões associada a um possível baixo travamento inicial decorrente do posicionamento quase que exclusivamente em osso trabeculado pode levar o implante a não osseointegrar. Por meio do estudo observacional longitudinal foi possível observar que quando bem indicados os implantes e suas respectivas próteses apresentam uma excelente taxa de sucesso no primeiro ano de função. Neste período inicial de osseointegração, onde a mesma já foi adquirida, a perda óssea marginal pôde ser prevista principalmente por meio do diâmetro da plataforma do implante e do tipo de retenção protética existente. Mais especificamente, plataformas com diâmetro de 3,5 mm e próteses cimentadas foram mais frequentemente associadas à perda óssea marginal. Porém, mesmo que estes fatores tenham sido demonstrados como muito importantes na previsão da perda óssea marginal, os mesmos não são capazes de prevê-la de forma isolada, sendo necessária a associação com fatores peri-implantares e relacionados à oclusão. Pois o risco de perda óssea marginal dos implantes no primeiro ano de função atingiu maiores valores de previsão quando associados aos fatores implanto-protéticos, estavam presentes ainda, esquemas oclusais inadequados e deficiência na largura de gengiva queratinizada. Nesse sentido, como a largura de gengiva queratinizada inferior a 3 mm pode prever a perda óssea marginal em segunda instância, é possível que a realização de cirurgias prévias a instalação da prótese sobre implante com o intuito de aumentar a quantidade de mucosa queratinizada possa levar a uma prevenção da perda óssea marginal no primeiro ano de função. Momento este no qual os tecidos ósseos ainda estão desenvolvendo maior densidade e maturação, apresentando ainda deposição de minerais na matriz formada nos estágios iniciais da osseointegração. Outro ponto importante a ser levado em consideração nesse período inicial é o esquema oclusal adotado pelo cirurgião-dentista para que haja um carregamento gradativo dos tecidos de suporte, visto que guias de desoclusão inadequadas, contatos prematuros e traumáticos foram associados a um maior risco de perda óssea marginal quando o diâmetro da plataforma do implante apresentou-se reduzido.

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Apêndices

Apêndice A — Termo de Consentimento Livre e Esclarecido

Termo de Consentimento Livre e Esclarecido

Título da Pesquisa: Avaliação da influência do uso de placas interoclusais na perda óssea marginal de implantes.

Pesquisadores:
Prof. Esp. Manuel Tomás Borges Radaelli.
Endereço: Rua Senador Pinheiro, 224; CEP 99070-220. Passo Fundo - RS
Fone: (54) 3313-0807. Email: manuelradaelli@gmail.com

Profa. Dra. Noeli Boscato;

Objetivos: Este estudo clínico longitudinal, tem como objetivo avaliar a influência do uso de placa interoclusal, confeccionada em resina acrílica termopolimerizável, na perda óssea ao redor dos implantes instalados em pacientes bruxômas.

Procedimentos: Será realizada uma radiografia periapical convencional dos implantes, antes e após terapia com placas interoclusais. Adicionalmente, serão realizados exames clínicos intra-bucais onde será avaliado as próteses implanto-suportadas, os tecidos peri-implantares e a oclusão. Será avaliada, ainda, a placa interoclusal em uso.

Riscos: Os procedimentos que serão realizados nesta pesquisa não oferecem risco algum aos seus participantes.

Benefícios: De forma direta, os pacientes serão avaliados quanto à presença de complicações nas próteses implanto-suportadas e seus respectivos implantes, contribuindo para a prevenção de futuras complicações e para a manutenção da saúde peri-implantar. De forma indireta, os resultados desta pesquisa irão contribuir na compreensão dos fatores que influenciam a perda óssea em implantes dentários, beneficiando assim, outros pacientes que possuem situação semelhante a dos pacientes avaliados pela pesquisa.

Remuneração: Não haverá nenhum tipo de remuneração para os pacientes participantes da pesquisa.

Eu,_______________________________________, RG n°_________________, abaixo assinado, tendo recebido todos os esclarecimentos acima citados e ciente dos meus direitos aceito de forma livre e esclarecida participar desta pesquisa, bem como autorizo a utilização dos dados clínicos e imagens dele resultantes para fins didático-científicos, desde que minha identidade seja preservada. Foi-me assegurado, também, que posso retirar a permissão para utilização deste material com fins didáticos, a qualquer tempo e por qualquer motivo por mim determinado, sem nenhum prejuízo ao tratamento a ser realizado.

Passo Fundo, ______ de ________________ de 20____.

___________________________________ ___________________________________

Assinatura do Paciente | Assinatura do Pesquisador

Apêndice B — Nota da Tese

Níveis de tensão e perda óssea peri-implantar

Peri-implant stress levels and bone loss

A presente tese de doutorado foi dividida em dois capítulos. Foram apresentados uma análise de elementos finitos e um estudo observacional longitudinal. O estudo de elementos finitos permitiu observar que as placas oclusais de resina acrílica deveriam ser recomendadas para bruxômas que realizam tratamento com implantes dentários, com a finalidade de proteger os implantes, componentes protéticos e tecidos ósseos peri-implantares das tensões deletérias induzidas pelas forças parafuncionais. Adicionalmente, o comprimento do implante e a profundidade de sua inserção podem ser usadas para diminuir a concentração de tensões na superfície da crista óssea alveolar. O estudo observacional demonstrou que a perda óssea peri-implantar é influenciada não apenas pelas características relacionadas especificamente aos implantes, mas também pelo efeito combinado com fatores oclusais e características peri-implantares.

Campo da pesquisa: Clínica Odontológica e Materiais Odontológicos.

Candidato: Manuel Tomás Borges Radaelli, Cirurgião-dentista pela Universidade Federal de Santa Catarina (2010)

Data da defesa e horário: 27/07/2017, às 13h30

Local: Auditório do Programa de Pós-graduação em Odontologia da Universidade Federal de Pelotas. 5o andar da Faculdade de Odontologia de Pelotas. Rua Gonçalves Chaves, 457.

Membros da banca: Prof. Dr. Aloísio Oro Spazzin, Prof Dr. Ataís Bacchi, Prof. Dr. Mateus Bertolini Fernandes dos Santos e Prof. Dr. Rafael Ratto de Moraes

Orientadora: Profa. Dra. Noéli Boscato

Informação de contato: Manuel Tomás Borges Radaelli,manuelradaelli@gmail.com
Rua Senador Pinheiro, 304. Faculdade Meridional (IMED). Passo Fundo - RS.

Apêndice C — Súmula do currículo do candidato

Súmula do currículo

Manuel Tomás Borges Radaelli nasceu em 18 de fevereiro de 1988, em Marau, Rio Grande do Sul. Completou ensino fundamental em Escola pública na mesma cidade, e ensino médio em Escola particular, em Erechim (RS). No ano de 2006 ingressou na Faculdade de Odontologia da Universidade Federal de Santa Catarina (UFSC), tendo sido graduado cirurgião-dentista em 2010. No mesmo ano iniciou atividade profissional em clínica particular e ingressou na Especialização de Prótese Dentária do Centro de Estudos Odontológicos Meridional (CEOM), concluindo em 2012 com uma monografia relatando uma pesquisa clínica. No ano de 2013 iniciou atividade docente na Faculdade Meridional (IMED) e ingressou no Doutorado do Programa de Pós-graduação em Odontologia da Universidade Federal de Pelotas (UFPel), área de concentração Materiais Odontológicos, sob a orientação da Profª. Drª. Noéli Boscato. Durante o período de doutorado desenvolveu pesquisa *in vitro* e estudo observacionai longitudinal.

Publicações:

SPAZZIN, A. O.; RADAELLI, M. T. B.; ALESSANDRETTI, R.; SCHERER, C. B. Pilar de zircônia personalizado com base metálica para prótese unitária sobre implante. *Prosthesis Laboratory in Science*, 6(21), 30-35, 2016.

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Anexos

Anexo A — Carta de aprovação do Comitê de Ética em Pesquisa

FACULDADE MERIDIONAL - IMED/RS

PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: Avaliação das tensões peri-implantares decorrentes de diferentes materiais dentários e influência do uso de placas interoclusais na perda óssea marginal em implantes dentários. Análise de elementos finitos e estudo clínico retrospectivo.
Manuel

Pesquisador: Manuel Tomás

Área Temática:

Versão: 1

CAAE: 34042214.2.0000.5319

Instituição Proponente: Faculdade Meridional - IMED

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 752.950

Data da Relatoria: 06/08/2014

Apresentação do Projeto:

Projeto de TCC de Odontologia, cujo título é: "Avaliação das tensões peri-implantares decorrentes de diferentes materiais dentários e influência do uso de placas interoclusais na perda óssea marginal em implantes dentários. Análise de elementos finitos e estudo
clínico retrospectivo."

Objetivo da Pesquisa:

Avaliar a influência do uso de placa interoclusal acrílica na perda óssea marginal em torno dos implantes instalados em pacientes bruxômas.

Avaliação dos Riscos e Benefícios:

RISCOS:Os procedimentos que serão realizados nesta pesquisa não oferecem risco algum aos seus participantes.

BENEFÍCIOS:

De forma direta, os pacientes serão avaliados quanto à presença de complicações nas próteses

Endereço: Senador Pinheiro 304
Bairro: centro **CEP:** 99.070-220
UF: RS **Município:** PASSO FUNDO
Telefone: (54)3045-6100 **Fax:** (54)3045-6107 **E-mail:** cep@imed.edu.br

implantossuportadas e seus respectivos implantes,
contribuindo para a prevenção de futuras complicações e para a manutenção da saúde peri-implantar. De forma indireta, os resultados desta
pesquisa irão contribuir na compreensão dos fatores que influenciam a perda óssea em implantes dentários, beneficiando assim, outros pacientes
que possuem situação semelhante a dos pacientes avaliados pela pesquisa

Comentários e Considerações sobre a Pesquisa:

Este será um estudo clínico do tipo retrospectivo longitudinal onde será realizada uma seleção previa de pacientes tratados no Centro de Estudos
Odontológicos Meridional – CEOM, Passo Fundo/RS. Após, será realizado um diagnóstico de bruxismo para se obter a amostra e então será
realizada a coleta de dados dos pacientes incluídos na pesquisa, para posterior análise estatística.

Considerações sobre os Termos de apresentação obrigatória:

Os termos estão apresentados!

Recomendações:

Conclusões ou Pendências e Lista de Inadequações:

O Projeto tem parecer favorável a sua execução!

Situação do Parecer:

Aprovado

Necessita Apreciação da CONEP:

Não

Considerações Finais a critério do CEP:

O Comitê de Ética da Faculdade Meridional / IMED decidiu pela aprovação do projeto. O pesquisador responsável deverá encaminhar, através de uma emenda de projeto,
qualquer modificação no protocolo original.

O relatório final deverá ser enviado até o dia 15/03/2015, conforme modelo do CEP/IMED. O CEP/IMED está a disposição para qualquer esclarecimento.