Leonardo Henrique Vadenal Panza
Cirurgião-Dentista

Avaliação da manutenção da pré-carga de parafusos de ouro e titânio em próteses implanto-suportadas.

Dissertação de Mestrado apresentada à Faculdade de Odontologia de Piracicaba da Universidade Estadual de Campinas para obtenção do Título de Mestre em Clínica Odontológica – Área de Prótese Dental

Orientadora: Prof^{a}. Dr^{a}. Altair Antoninha Del Bel Cury

Piracicaba
2006

FICHA CATALOGRÁFICA ELABORADA PELA
BIBLIOTECA DA FACULDADE DE ODONTOLOGIA DE PIRACICABA
Bibliotecário: Marilene Girello – CRB-8ª. / 6159

P196a	Panza, Leonardo Henrique Vadenal. Avaliação da manutenção da pré-carga de parafusos de ouro e titânio em próteses implanto-suportadas. / Leonardo Henrique Vadenal Panza. -- Piracicaba, SP : [s.n.], 2006. Orientador: Altair Antoninha Del Bel Cury. Dissertação (Mestrado) – Universidade Estadual de Campinas, Faculdade de Odontologia de Piracicaba. 1. Próteses e implantes. 2. Reabilitação bucal. 3. Implantes dentários. I. Del Bel Cury, Altair Antoninha. II. Universidade Estadual de Campinas. Faculdade de Odontologia de Piracicaba. III. Título. (mg/fop)

Título em Inglês: Pre-load maintenance in abutment and prosthetic screws implant restoration after simulated load cycling: an in vitro study
Palavras-chave em Inglês (Keywords): 1. Prostheses and implants. 2. Mouth rehabilitation. 3. Dental implants
Área de Concentração: Prótese Dental
Titulação: Mestre em Clínica Odontológica
Banca Examinadora: Altair Antoninha Del Bel Cury, Paulo Martins Ferreira, Mauro Antonio de Arruda Nóbilo
Data da Defesa: 01-12-2006
Programa de Pós-Graduação: Clínica Odontológica

UNIVERSIDADE ESTADUAL DE CAMPINAS
FACULDADE DE ODONTOLOGIA DE PIRACICABA

A Comissão Julgadora dos trabalhos de Defesa de Dissertação de MESTRADO, em sessão pública realizada em 01 de Dezembro de 2006, considerou o candidato LEONARDO HENRIQUE VADENAL PANZA aprovado.

PROFa. DRa. ALTAIR ANTONINHA DEL BEL CURY

PROF. DR. PAULO MARTINS FERREIRA

PROF. DR. MAURO ANTONIO DE ARRUDA NÓBILO

Dedico esta dissertação,

Aos meus avós **Gonçalo Vadenal, Laurindo Panza e Maria Aparecida Menim Panza**, que onde quer que estejam devem estar muito felizes hoje.

Aos meus pais **Lauro** e **Rita**, minha avó **Lydia**, e meus tios **Ricardo** e **Regina** por toda confiança e incentivo em mim depositados. É graças a vocês que continuo sempre em frente.

A **Maria Isabel,** que sempre soube ter paciência e me entender, até nas horas em que isso parecia impossível, conseguindo colocar calma e paz em minha vida, me tornando uma pessoa cada dia mais feliz.

AGRADECIMENTOS ESPECIAIS

A **Deus**, por me proporcionar tantas boas oportunidades.

A minha orientadora, ***Profa. Dra. Altair Antoninha Del Bel Cury***, exemplo incontestável de capacidade intelectual e pessoa de índole fantástica, pela capacidade de me ajudar a fazer este trabalho com uma orientação segura e precisa.

A ***Profa. Dra. Renata Cunha Matheus Rodrigues-Garcia***, pela disposição constante em ajudar e pelo exemplo de dedicação e amor à prática docente.

A ***Profa. Dra. Noeli Boscato*** pela ajuda na elaboração deste projeto e na discussão dos resultados e sua incansável vontade de aprimoramento deste trabalho.

AGRADECIMENTOS

À **Universidade Estadual de Campinas** por meio do seu Magnífico Reitor, Prof. Dr. José Tadeu Jorge.

À **Faculdade de Odontologia de Piracicaba da Universidade Estadual de Campinas**, na pessoa de seu Diretor, Prof. Dr. Thales da Rocha Mattos Filho.

Ao Coordenador dos Cursos de Pós-Graduação da Faculdade de Odontologia de Piracicaba da Universidade Estadual de Campinas, **Prof. Dr. Mario Coelho Sinhoreti**

A Coordenadora do Programa de Pós-graduação em Clínica Odontológica da Faculdade de Odontologia de Piracicaba da Universidade Estadual de Campinas, **Profª. Drª. Renata Cunha Matheus Rodrigues Garcia**.

Aos Professores **Dr. Luiz André Freire Pimenta** e **Dra. Giselle Maria Marchi** responsáveis pelo laboratório de Dentística da Faculdade de Odontologia de Piracicaba, UNICAMP, agradeço pelo uso das instalações e pela permissão do uso dos equipamentos.

Ao Prof. Marcelo F. Mesquita, responsável pelo laboratório de Prótese Total da Faculdade de Oodntologia de Piracicaba, UNICAMP, pela permissão do uso do microscópio de medida.

Ao **Doutorando Maximiliano Sergio Cenci,** pela amizade, e disposição em ajudar com a elaboração da análise estatística deste trabalho.

As meus grandes e eternos amigos **Adriana Calvo, Alex Yutaka Fukabori, Alysson Martins Correa, André Boscariol Pacheco, Aristeu Peixoto Escobedo, César Akio Shinkawa, Diego Guilherme Dias de Rabello, Felipe Ramalho Ferreira, Fernando Rizzo Alonso, Gabriel Ramalho Ferreira, Guilherme Momesso Dias, Jefferson Tomio Sanada, Lourenço Catani, Lucele Vieira Marins, Mauricio Sergio Porto, Murilo Zucato de Oliveira, Nelson Trevisan Jr., Renato Boscariol Pacheco, Rodrigo Silva Caldas, Thiago Chon Leon Lau, Thiago Modolo Martins**, e os que aqui não estão relatados, mas sabem que fizeram parte da minha história, pela amizade, e força.

A amiga **Tatiana Pereira**, pessoa que admiro por seu caráter, inteligência e obstinação na busca de seus objetivos, a qual terá sempre minha admiração e amizade.

Ao amigo **Wander José da Silva**, pessoa de imenso coração, pelo companheirismo, amizade e ajuda em todas as horas.

Aos colegas da Pós-Graduação, **Maria Áurea Feitosa e Lucíola Maria Rodrigues De Vasconcelos, Carolina Beraldo Meloto, Devanir Silva Vieira Prado, Evilin Sanches Morais , Simone Guimarães Farias Gomes, Carolina Meloto, Fabiana Gouvea, William Custódio, Juliana Moura, Priscila Serrano, Fernanda Faot, Poliana Bastos, Devanir Prado, Luiz Gustavo Dias Daroz**, **Lígia Brasileiro**, **Mônica Cruz, Mônica Nogueira Pigozzo, Wagner Fragoso** e **Wagner Negreiros,** William Custodio pela convivência e por me proporcionarem vários momentos felizes.

A **Sra. Joselena Casati**, responsável técnica pelo Laboratório de Prótese Removível, pelo apoio e amizade.

À **Érica Alessandra Pinho Sinhoreti** e **Raquel Q. Marcondes Cesar Sacchi** secretárias da Coordenadoria Geral dos Programas de Pós-

graduação; **Mônica Aparecida Barnabé**, secretária do Programa de Pós-graduação em Clínica Odontológica; **Shirley Rosana Sbravatti Moreto**, e **Juliana de Souza** respectivamente secretária e estagiária do Departamento de Prótese e Periodontia meu sincero agradecimento pela atenção e gentileza dispensada durante esses anos de convívio como aluna de pós-graduação.

A **Fundação de Amparo a Pesquisa do Estado de São Paulo**, FAPESP, pela bolsa concedida, sob processo 04/04911-4.

A empresa **Conexão Sistemas de Prótese**, que gentilmente doou grande parte dos componentes utilizados neste trabalho.

A todos que direta ou indiretamente contribuíram para a realização deste trabalho.

FÉ

ATITUDE

TRABALHO

PERSEVERANÇA

RESUMO

O sucesso da terapia reabilitadora com implantes requer um equilíbrio entre fatores biológicos e mecânicos. Os fatores biológicos são multifatoriais, já os mecânicos associam-se à instabilidade da conexão implante-parafuso-intermediário. Entre os fatores responsáveis pela manutenção da estabilidade desta conexão, a manutenção da pré-carga do parafuso é o mais importante. Com base nestas informações, este estudo buscou avaliar a manutenção da pré-carga de parafusos de ouro, após a aplicação de carga simulada, por meio da realização de ciclagem mecânica do conjunto protético, e também observar a ocorrência de rotação da coroa ou do intermediário protético em relação aos implantes. Para tanto, foram utilizados 40 implantes, 20 com hexágono interno e 20 externo, conectados a intermediários protéticos do tipo Esteticone com angulação de 17° e sem angulação, todos retidos por parafusos de titânio rosqueados a 20N/cm, sobre os quais foram parafusadas coroas confeccionadas em resina acrílica simulando pré-molares superiores humanos com parafusos de ouro apertados a 10N/cm. Cada conjunto foi então submetido ao ensaio de fadiga com aplicação de forças médias de 115 N no sentido do longo eixo do implante por 0.2 s, com uma freqüência de 1 Hz, totalizando um total de 250.000 de ciclos (correspondendo aproximadamente a 3 meses de uso). A manutenção da pré-carga dos parafusos, foi avaliada pelo destorque dos parafusos, após a realização do ensaio de fadiga, com a utilização de um torquímetro digital. Os resultados foram então submetidos à análise de variância a 2 critérios e ao teste de Tuckey, através dos quais foi possível observar que, para o parafuso protético, ocorreu diferença estatisticamente significante entre os tipos de implante, mas sem interação com o tipo de intermediário. No entanto para o parafuso do intermediário ocorreu diferença significativa tanto para o tipo de implante como entre os intermediários, com interação entre os fatores. A análise estatística apontou um desempenho melhor para a manutenção da pré-carga inicial dos parafusos, nos intermediários angulados tanto nos implantes de hexágono interno, quanto nos de hexágono externo. Nenhum dos corpos de prova apresentou rotação de coroa ou intermediário protético quando analisados ao microscópio.

Palavras-chaves: reabilitação oral, implantes dentais, próteses e implantes.

ABSTRACT

After osseointegration failures, screw loosening is the most common problem in implant dentistry. However, controversies still exist regarding to the influence of type connection implant to abutment in screw loosing or fracture.

This study evaluated pre-tightening maintenance in abutment and prosthetic screws of external and internal implant hexagon with standard and 17° angulated abutments after fatigue testing. Also, the rotational dislodgement was checked using digital measurement microscope.

Four subsets (n=10) of implants and abutments were assessed: (G1) internally hexed implant and standard abutment (G2) internally hexed implant and 17° angulated abutment (G3) externally hexed implant and standard abutments (G4) externally hexed implant and 17° angulated abutment. Abutments were retained by titanium screws tightened to 20 N/cm. Acrylic resin crowns were manufactured and were retained over the abutments with gold screws tightened at 10 N/cm, using an electronic torque controller. A vertical line was ascribed across the implant-abutment and crown-abutment interface to identify any rotational displacement. The fatigue tests were performed in a servo-hydraulic machine which delivered forces between 100 and 120 N for 250,000 cycles, through a piston to the crown. The implant-abutment interface were evaluated using a light microscope. Then, screw was removed and detorque value was recorded. Data were statistically analyzed using ANOVA and Tukey test (α=.05)

No horizontal displacement of acrylic resin crown and abutments were observed.

ANOVA showed significant difference for prosthetic screw between implant types, but without interaction with abutment. However, for abutment screw, there was a significant difference between implant type and abutment. Also, it was observed interaction between implant and abutments types. Internally hexed implants (G1 and G2) and externally hexed implants (G3 and G4) showed significant difference with a better performance for angulated abutment in comparison to standard abutment.

Within the limitations of this study it was concluded that pre-tightening maintenance of screw was affected by the type of abutment and the type connection implant used. There was no dislodgement for crown or abutment when standard or pre-angulated abutments were used after 250.000 cycles of simulated loading. Indeed, internal and external hexed connections were effective to avoid rotation of crowns.

Keywords: oral rehabilitation, dental implants, implant abutments

SUMÁRIO

INTRODUÇÃO GERAL

Desde que foi introduzido o conceito de osseointegração, os implantes dentais tornaram-se uma opção viável de tratamento para pacientes desdentados (Branemark, 1985; Jemt, 1981). O bom resultado de um tratamento com implantes depende basicamente de um equilíbrio entre fatores biológicos e mecânicos. Os fatores biológicos geralmente são multifatoriais, já os mecânicos associam-se à instabilidade da conexão implante-parafuso-intermediário protético (Goodacre CJ, 1999).

Entre os fatores biológicos é imprescindível o correto relacionamento do implante com o rebordo alveolar e dentes adjacentes. (Rubenstein, 1999) Contudo, é comum a existência de diferenças entre o longo eixo do implante e dentes remanescentes. Para resolução dessa situação houve a necessidade do desenvolvimento de intermediários de diferentes angulações.(Bickford JH, 1981)

Para tanto, os fabricantes de sistemas de implantes oferecem intermediários com angulações que variam de 0° a 60°, sendo possível até a fabricação de angulações personalizadas com o sistema CAD-CAM.(Marchack CB, 1996; Sethi A, 2002). Os intermediários protéticos angulados são utilizados para compensar as possíveis discrepâncias de angulação e posicionamento do implante e conferir à prótese função e estética adequadas. Contudo, o uso de angulações em intermediários pode em alguns casos, ocasionar problemas relacionados aos fatores mecânicos e biológicos devido à transmissão de forças não se dar paralelamente no longo eixo do implante (Sendyk CL, 1998).

Estudos que avaliaram as falhas ocorridas em implantodontia, afirmam que se o eixo da coroa protética não for coincidente com o longo eixo do implante, devido à incidência de carga que ocorre durante a mastigação, existe o risco de que o braço de alavanca formado desde o contato oclusal até o longo eixo do implante contribua para o destorque do parafuso e possíveis fraturas.

O mesmo acontece quando a altura excessiva do complexo intermediário-coroa está presente, aumentando-se o braço de alavanca para os componentes do sistema protético, provocando os mesmos riscos de destorque e fratura do parafuso (Renouard F, 2001).

Os fatores mecânicos são responsáveis pela estabilidade do sistema implante-parafuso-intermediário protético. A desadaptação máxima entre os componentes implante/conexão protética aceitável seria da ordem de 10μm, precisão nem sempre atingida. A falta de uma perfeita adaptação compromete a adaptação passiva dos componentes que seria um dos pontos-chave para o sucesso do tratamento.(Branemark PI, 1987; Binnon PP, 1995; Hecker DM, 1993; , Lie A, 1994; Rangert B, 1989; Renouard F, 2001) A falta de passividade tem sido apontada em estudos clínicos prospectivos como causadora de vários tipos de complicações protéticas, principalmente em casos de próteses múltiplas, tais como: perda (destorque) ou fratura do parafuso e outros componentes (Cox JF, 2001;. Hemmings KW, 1994).

A perda do parafuso é descrita como uma das conseqüências da não manutenção do torque inicial, ou pré-carga, exercida sobre a cabeça do parafuso durante adaptação da interface implante-intermediário protético (Lee JH, 2002; Byrne D, 2006) Essa pré-carga do parafuso é responsável por assegurar a resistência à fadiga e o efeito de travamento da conexão implante-intermediário, pois esforços mastigatórios resultam em forças sobre a prótese implanto-suportada que podem causar destorque do parafuso, o que implicaria na sua perda (Shigley JE, 1986) O mecanismo de perda ou fratura de componentes está mais bem elucidado no campo da Engenharia, área na qual é consenso que a adaptação da superfície da cabeça do parafuso à conexão é vital para a manutenção da pré-carga. , do que na Odontologia, onde ainda existem controvérsias de acordo com os estudos de Jemt, T, 1991; Lekholm U, 1999; Marchack CB, 1996; Wie H, 1995.

Irregularidades na conexão implante-parafuso-intermediário também causam estresse nos parafusos, podendo causar instabilidade no sistema. Alguns autores sugerem que a estabilidade dessa conexão é diretamente relacionada à adaptação entre as paredes do hexágono do implante e as paredes do intermediário em contato com estas, embora os hexágonos apresentem um pequeno grau de liberdade entre eles de até 5°. (Binnon PP1995; Rubenstein JE, 1999).

Sobre a influência da conexão, interna ou externa, utilizada na manutenção da estabilidade da prótese, existe uma discussão acerca dos valores de destorque para os dois sistemas. Breeding (1993), por exemplo, encontrou valores de destoque do parafuso piores e fratura de conexões implante-intermediário quando usado hexágono interno. Contrariando estes resultados, pesquisas demonstram uma maior incidência de destorque e fratura de parafusos de conexões implante-intermediário, quando usado hexágono externo. (Goodacre CJ, 1999)

Entre fabricantes e pesquisadores existem dúvidas quanto à influência das conexões interna e externa na manutenção da estabilidade do conjunto da prótese implanto-suportada, sendo que alguns sugerem que a presença do hexágono não seria o ponto crucial no sucesso do procedimento e sim a manutenção da pré-carga e otimização da aplicação do torque. (Binnon PP, 1995)

Testes de fadiga de materiais, têm sido usados para avaliar a resistência à mastigação simulada dos componentes utilizados em reabilitações implanto-suportadas. Estes testes baseiam-se em ciclos de aplicação de carga que varia entre 100 N e 200 N que simulam o movimento da mastigação, após a aplicação do torque indicado para cada componente pelo fabricante. (Cibirka RM, 2001; Lee J, 2002)

Visando esclarecer tais dúvidas, o presente estudo buscou avaliar a manutenção de pré-carga de parafusos de ouro, em implantes de conexão interna e externa, quando usados intermediários angulados e convencionais, após a ciclagem mecânica.

CAPÍTULO 1

Capítulo 1: Pre-load maintenance in abutment and prosthetic screws implant restoration after simulated load cycling: an *in vitro* study.

Este artigo foi submetido à publicação no: ***International Journal of Oral Maxillofacial Implants.*** no mês de novembro de 2006

Pre-load maintenance in abutment and prosthetic screws implant restoration after simulated load cycling

[a]Leonardo Henrique Vadenal Panza, DDS; [b]Noeli Boscato, DDS MSc, PhD; [c]Altair Antoninha Del Bel Cury, DDS MSc, PhD

[a] Graduate Student, Department of Prosthodontics and Periodontology, School of Dentistry of Piracicaba, State University of Campinas.
[b] Assistant Professor, Department of Prosthodontics, School of Dentistry of University of Oeste de Santa Catarina.
[c]Professor and Chair, Department of Prosthodontics and Periodontology, School of Dentistry of Piracicaba, State University of Campinas.

Correspondence to::

Dr. Altair A. Del Bel Cury

Av. Limeira, nº 901, Piracicaba, SP, CEP 13.414-903
Phone number: + 55-19- 2106-5294

Fax number: + 55-19- 2106-5218
e-mail: altcury@fop.unicamp.br

Pre-load maintenance in abutment and prosthetic screws implant restoration after simulated load cycling

ABSTRACT

Purpose: This study evaluated pre-tightening maintenance in abutment and prosthetic screws of external and internal hexagon implant with straight and 17° angled abutments after fatigue testing.

Material and methods: Four groups (n=10) of implants and abutments were assessed: (G1) implant with an internal hexagon (Conect AR®) and straight Estheticone® abutment; (G2) implant with an internal hexagon (Conect AR®) and 17° angled Estheticone® abutment; (G3) implant with an external hexagon and straight Estheticone® abutment; (G4) implant with external hexagon and 17° angled Estheticone® abutment. All implants were 3.75mm of platform and 10 mm in length Abutments were retained by titanium screws tightened to 20 N/cm and acrylic resin crowns were retained over the abutments with gold screws tightened at 10 N/cm, using an electronic torque controller. A vertical line was ascribed across the implant-abutment-crown interface aiming to verify horizontal displacement by an light microscope at 40 X magnification. The fatigue tests were performed in a servo-hydraulic machine, which delivered forces between 100 and 120 N for 250,000 cycles, through a piston to the crown. Then, screw was removed and detorque value was recorded. Data were statistically analyzed using the 2-way ANOVA and Tukey test (α=.001)

Results: No horizontal displacement was observed on the interface of implant-abutment or abutment and crown. The 2 way ANOVA showed significant difference for prosthetic screw between implant connection types, but without interaction with abutment ($P<.001$). However, for abutment screw, there was a significant difference between implant connection types and abutment and interaction between implant and abutments ($P<.001$).Significant difference was observed between straight and 17° angled abutment (P.001) with better performance for the former..

Conclusion: Within the limitations of this study, it was concluded that the connection implant types or abutment types affected pre-tightening maintenance. Indeed, internal and external hexed connections were effective to avoid horizontal displacement of crowns.

Keywords: oral rehabilitation, dental implants, implant abutments

INTRODUCTION

Despite the successful clinical outcomes Branemark's[1], some problems in implant therapy are still considered insurmountable. Studies have shown that after osseointegration failures, screw loosing, or fracture of its abutment screws and prosthetic retaining screw are still considered the most important of problems and can affect the success of implant restorations[2]. Furthermore, mechanical failures have been associated with screw joint instability between the abutment and the implant.[3]. In addition, there is a controversial about the influence of implant-abutments joint in screw loosing or fracture.[4]

Regarding to implants connection type Goodacre et al[5] (1999) and Balfour & O'Brien,[6] (1995) reported best results when internal hexagon design implants were used, while Khraisat et al[7] (2004) considered that external hexagon implant system reduced the problem of screw loosening or fracture. On the other hand, Breeding et al,[8] (1993) described failure, due to biomechanics problem, either internal or external hexagon implant systems were used.

Besides the problem with the implant connection system, the use of angled abutments is also related to screw loosing or fracture due to the occlusal forces do not be directed along the implant axis..[9] However, the angled abutment is very useful, considering the anatomy of the jaw and the morphology of the residual ridge, which is a determining factor in the orientation and angulations in which the implants should be placed. In those cases where there is a difference between the long axis of the inserted implant and long axis of the planned tooth replacement, it should be used an angled abutment to produce functional and esthetic restorations.[9]

Moreover, implant manufactures have recognized that screw loosing is a significant problem and have attempted to solve this problem. For instance, either internal or external hexagon was incorporated to act as a stabilizer for screw joint. Even though these antirotational design characteristics were incorporated into the implant system, machining tolerances still allow small amount of movement between the abutment and implant that the clamping action of the screw prevent.[10]

Although there are many studies about joint screw failures, the effect of angled abutments in the maintenance of stability of the screw joint, as well as the influence of implants connection type in screw joint failures remains a concern. Thus, this study was designed to evaluate the pre-tightening maintenance of titanium abutment screw and gold prosthetic screw using internal and external hexagon implants and straight and **17°** angled abutment after a simulated cycling load. The horizontal displacement between implant-abutment and abutment- crown interface was also recorded.

MATERIAL AND METHODS

In this study, it was used 40 specimen consisting of implants, abutments, screws of titanium, acrylic resin crowns and gold screws divided into 4 groups of 10 assemblies each: (G1) implant with an internal hexagon (Conect AR®) and straight Estheticone® abutment; (G2) implant with an internal hexagon (Conect AR®) and 17° angled Estheticone® abutment; (G3) implants with an external hexagon (Master Screw®) and straight Estheticone® abutment; (G4) implant with external hexagon (Master Screw®) and 17° angled Estheticone® abutment. All implants were 3.75mm of diameter and 10 mm in length and all were bought from Conexão, Sistemas de Próteses, São Paulo, Brasil.

Each implant was embedding to the level of collar in a polyester resin block (diameter: 22mm), using a surveyor guide (Bioart, 1000N, São Paulo, Brazil) so that the tip of the stylus would contact the acrylic resin crown on each sample to the center of the abutment. Standardized acrylic resin crowns were fabricated for each assembly. For this, a metallic master model simulating a human pre molar was duplicate, using a high precision elastomeric material (Elite Double 8, Zhermack, Italy), and the crowns were made using self polymerized acrylic resin (Classico Artigos Odontológicos Ltd, Sao Paulo, Brazil).over the implant components (Conexão, Sistemas de Próteses, São Paulo, Brazil) .

After a minimum of 24 hours post implants placement in the polyester resin, each abutment screw of the test groups was tightened to a torque of 20 N/cm. After 10 minutes, the abutment screw was again tightened to 20 N/cm. Then, the crown was positioned and each prosthetic gold screw was tightened applying a 10N/cm. The load torque used was in accordance with the manufacturer's instructions. A torque controller device (Lutron Eletronics TM 800, Taipei, Taiwan) was used to ensure that an accurate and reproducible strength was applied to each abutment or prosthetic screw. Furthermore, each implant was rigidly held in a special holding device (figure I) during screw tightening to ensure rigid fixation without rotation during the tightening. Follow this procedure a vertical line was scribed using a bur across the implant-abutment and abutment-crown interface (figure II) to evaluate horizontal displacement.[3]

FIGURE I and II

After, the specimens were placed in a cyclic loading machine with 10 piston heads activated by an air compressor (ERFOP 10, Erios, São Paulo, Brazil). The temperature of each specimen was maintained at 37°C by means a distilled water bath. The dynamic load was applied in a 2 mm square area to the occlusal fossa of each crown by a unidirectional vertical piston calibrated under displacement control, cycling between 100 and 120 N. Cycling loading continued for 250,000 cycles, simulating a 3 months period of *in vivo* mastication approximately.[3,11]

After the test completion, each specimen was removed from the mechanical fatigue machine and microscopically inspected for horizontal displacement in a tri-dimensional digital measurement microscope (Walter Uhl, Asslar, Germany). The observation was performed 3 times by sample by one single operator. The images were captured and analyzed in appropriate software (VideoCap 32, Microsoft, USA). Specimens were then replaced in the rigid holding device to ensure rigid fixation without rotation for detorque of the screws. The electronic controller device was carefully maintained in the long axis of the implant with the driver seated in the screw head. Abutment and prosthetic screws were removed and detorque values recorded in N/cm. After this procedure, screw and abutment surfaces were examined to verify any fracture occurrences.

Statistical analysis

The statistical analysis was done using SAS software (SAS Institute Inc., version 9.0, Cary, NC) employing a significance level fixed at $p<0.001$. The 2-way ANOVA was used to test the null hypothesis of no difference between implant connection types and detorque of screws either abutment or prosthetic screws. The assumptions of equality of variances and normal distribution of errors were checked...Tukey's test was then used for post-ANOVA comparisons.

RESULTS

The results are presented in tables 1, 2 and 3.

Table I.. 2-way ANOVA for prosthetic screw detorque in accordance with implant connection types and abutment types

Source	*df*	SS	MS	F	P
Implant	1	14.02	14.02	22.35	<.0001
Abutment type	1	0.09	0.09	0.15	0.6978
Implant x abutment	1	0.05	0.05	0.08	0.7828

Table II. 2-way ANOVA for abutment screw detorque in accordance with implant connection types

Source	*df*	SS	MS	F	P
Implant	1	0.63	0.63	0.05	0.8189
Abutment	1	950.06	950.06	80.58	<0.001
Implant x abutment	1	144.33	144.33	12.24	<0.0013

Table III- Detorque values (N/cm) in abutment screw after fatigue test. (Mean ± SD)

Implant connection type	Straight abutment	17° Angled abutment
Internal hexagon	5.6±1.1Aa	7.7±0.9Ab
External hexagon	4.0±1.8 Ba	8.7±1.1Bb

Capital letters denote difference between implant connections types and lower case letters between abutment types (Tukey test, P<.001)

The analyses of the interface between implant-abutment and abutment-crown showed no displacement when the vertical lines were observed.

The detorque values for prosthetic screws regarding the connection implant types (internal and external hexagon), showed significant differences by the 2- way ANOVA (P<.0001), but without interaction with the implant types. (table I).

Abutment screw detorque was affected by the connection implant types and by abutment either straight or angled (P<.001) (table II). The 17° degree angled abutment showed the higher values for detorque independent of implant connection types (*P<.001*) by Tukey test (table III).

Discussion

The stability of implant-abutment connection and propensity for screw loosing is also influenced by the preload. and the contacting areas of implant and abutment. Tightening the screw creates the tension in the screw necessary to keep the components together[12]. Still according to Binon[13], (2000), the resistance to avoid loosing screw is related to the joint preload. Thus, as greater the joint preload, the greater the resistance.

In this study, we did not observed displacement in the interface either implant-abutment or abutment-crown when the vertically scribed lines were evaluated under high resolution microscope. Internal and external hexagon connections were effective to avoid rotation displacement. This result is consistent with findings of Cibirka et al.[3]

Regarding the implant connection types and prosthetic screw no interaction was found and no screw was lost. This findings could be explained by the fact that prosthetic screw preload was kept, considering that screw loosing occurs when the clamping force developed within the assembly is less than the forces which pull the assembly apart.[14]

Although statistical analysis showed significant differences between the implant connection types and abutment types regarding detorque abutment screw, the results do not allow to assert whether internal hexagon implant is better than external hexagon in maintenance of screw joint stability. The abutment screws detorque of the straight abutment showed better results when internal hexagon was used; on contrary, the angled abutment exhibited the higher detorque values for external hexagon. As preload can be influenced by component and screw materials[17,18], torque delivery system[19], manufacturer quality control[18], screw joint design[21], surface roughness[22], and fatigue testing[3,12] is very difficult to attribute the results to one of them. Moreover, Binnon,[4] (1996) in his study about implant-abutment misfit on screw joint stability concluded that the presence of the external implant hexagon increased resistance to screw loosing. In addition, Cibirka et al suggested that a less precise fit in the width of the hexagon space, or its total elimination, did not adversely affect the preload after fatigue testing.[3]

The better results found when angled abutment was used could be elucidate by a microscopically analysis of the relationship between abutment screw and internal implant threads. The distribution of the torque to the system depends on fitting between screw head and abutment platform, through friction between screw head and abutment and friction between the threads on the screw and implant; and the tension within the screw, defined as preload. [21] This condition probably could be better in angled abutment in comparison with straight abutment.

The lack of loosing screw observed in this study can be related to factors such as the amount of load applied, even it was applied the load suggested by the manufacturer, the location and direction of force application and the number of cycles applied during fatigue test. It is important to considerer that although the load is arbitrary, attempted to simulate the clinical conditions. The number of loading cycles used could be insufficient to cause screw joint deterioration as suggested by Bickford et al.[22] This consideration is in agreement with the study of

Binon & Mc Hugh[23], (1996) that concluded that joint failure did not occur until a mean of 5 million cycles for abutment screws tightened to 30 N-cm, whereas 20 N-cm of torque allowed failure to occur at 357162 cycles and in our study we used only 250000 cycles. Also, it was suggested that abutments tightened with 20N-cm could be expected to fail from screw loosing in 2 to 3 months. [10]

Even though no screw loosing or damaged screw either from abutment or prosthetic crown was found in this study, the better performance of 17° angled abutment in comparison with straight, new investigations about the influence of angled abutment in the maintenance of pre-tightening load should be conducted.

Conclusion

Within the limitations of this study we could conclude that the dynamics in maintenance pre load tightening is influenced by connections between the implant and abutment and by the abutment types; straight or angled. There was no crown or abutment displacement either straight or 17° angled abutments were used after fatigue test. Indeed, internal and external hexed connections were effective to avoid rotation of restorations.

Acknowledgements

This study was partially supported by FAPESP (Process 04/04911-4).

References

1. Branemark PI, Zarb G, Albrektsson T. Tissue-integrated prostheses: osseointegration in clinical dentistry. Special Edition for Nobelpharma. Chicago: Quintessence; 1987:268-71
2. Cho SC, Small PN, Elian N, Tarnow D. Screw loosening for standard and wide diameter implants in partially edentulous cases: 3 to 7 year longitudinal data.. Implant Dent 2004;13:245-50
3. Cibirka RM, Nelson, SK, Lang, BR, Rueggeberg FA. Examination of the implant-abutment interface after fatigue testing. J Prosthet Dent. 2001;85: 268-75
4. Binon PP. Evaluation of machining accuracy and consistency of selected implants, standard abutments and laboratory analogs. Int J Prosthodont 1996;8:162-78
5. Goodacre CJ, Kan JYK, Rungcharassaeng K Clinical complications of osseointegrated implants. J Prosth Dent 1999;81(5):537-552.
6. Balfour A, O'Brien GR. Comparative study of antirotational single tooth abutments. J Prosthet Dent. 1995 Jan;73(1):36-43.
7. Khraisat A, Abu-Hammad O, Dar-Odeh N, Al-Kayed AM. Abutment screw loosening and bending resistance of external hexagon implant system after lateral cyclic loading. Clin Implant Dent Relat Res. 2004;6(3):157-64
8. Breeding LC, Dixon D, Nelson EW, Tietge JD. Torque Rotational to Loosen Single-Tooth Implant Abutment Screws Before and After Simulated Function. Int J Prosthodont 1993;6:435-439.
9. Sethi A, Kaus T, Sochor P, Axmann-Krcmar D, Chanavaz M. Evolution of the concept of angulated abutments in implant dentistry: 14-year clinical data. Impl Dent 2002;11:41-50
10. Dixon DL, Breeding LC, Sadler JP, Comparison of screw loosing , rotation and deflection among three implant designs. JPD 1995; 74:270-278
11. Gibbs CH, Mahan PE, Mauderli A, Lundeen HC, Wals EK. Limits of human bite strength. J Prostht Dent 1986;56:226-9

12. Kano SC, Binon P, Bonfante G, Curtis DA. Effect of casting procedures on screw loosening in UCLA type abutments. J Prosthodont 2006; 15:77-81.
13. Binon PP. Implants and components: entering the new millennium. Int J Oral Maxillofac Implants. 2000; 15:76-94
14. Byrne D, Jacobs S, O'Connel B, Houston F, Claffey N. Preloads generated with repeated tightening in three types of screws used in dental implant assemblies. J Prosthodont. 2006;15:164-71
15. Haack JE, Sakagushi RL, Sun T et al. Elongation and preload stress in dental implant abutment screws. Int J Orl maxillofac Implants 1995; 10:529-536.
16. Martin WC, Woody RD, Miller BH et al. Implant abutment screw rotation and preload for four different screw materials and surfaces. JPD 2001; 86:24-32
17. Tan KB, Nicholls JI. Effect of 3 torque delivery systems on gold srew preload at the gold cylinder-abutmeent screw joint. It J Oral Maxillofac Implants 2002; 17:175-183.
18. Tan KB, Nicholls JI. Implant- abutment screw joint preload of 7 hex-top abutment systems. It J Oral Maxillofac Implants 2001; 16:367-377.
19. Schulte JK, Coffey J. Comparison of screw retention of nine abutment systems. A pilot study. Implant Dent 1997; 6:28-31.
20. Carr A B, Brunski JB, Hurley E. Effects of fabrication, finishing, and polishing procedures on preload in prostheses using conventional " gold" and "plastic" cylinders. Int J Oral Maxillofac Implants 1996;11: 589-598.
21. Shigley JE. Mechanical Engineering Design, ed 6. New York: McGraw Hill, 1977:446-457
22. Bickford JH. An introduction the design and behavior of bolted joints . New York : M. Dekker, 1981: 358-60.
23. Binon PP, Mc Hugh MJ MJ. The effect of eliminating implant/abutment rotational misfit on screw joint stability. Int J Prosthodontics 1996; 9:511-9.

FIGURE I

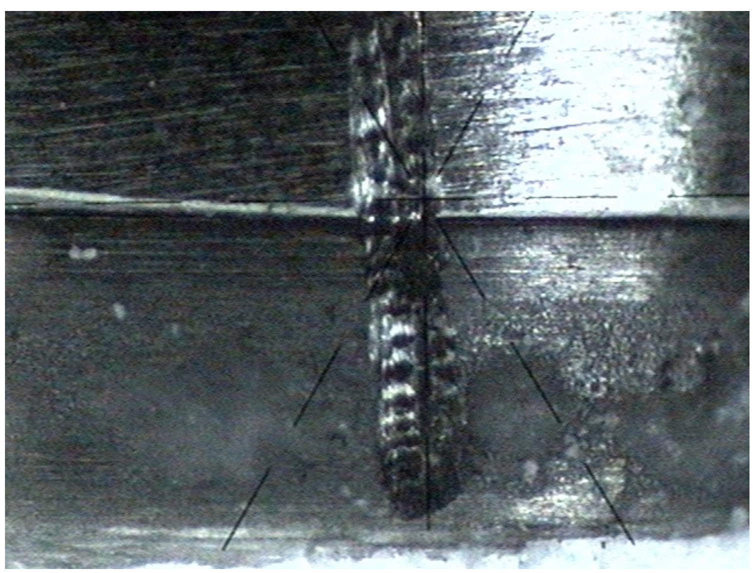

FIGURE II

CONCLUSÃO GERAL

Os resultados do presente estudo permitem afirmar que a manutenção da pré-carga de parafusos de titânio de intermediários protéticos e parafusos protéticos de ouro são influenciados pelo tipo de intermediário utilizado (Estheticone sem angulação e Estheticone pré-angulado de 17°). Porém apesar da perda de pré-carga não ocorreu deslocamento rotacional de coroas, nem de intermediários após mastigação simulada por 250.000 ciclos em ciclagem mecânica.

REFERÊNCIAS

1. Bickford JH. ***Advanced mechanics of materials***. Menlo Park, Calif**.** Addison-Wesley 1998: 460p
2. Breeding RC, Dixon D, Nelson EW, Tietge JD. Torque Rotational to Loosen Single-Tooth Implant Abutment Screws Before and After Simulated Function. ***Int. J. of Prosthodont***. 1993; 6: 435-439.
3. Branemark PI, Zarb G, Albrektsson T. ***Tissue-integrated prostheses***. Berlin: Quintessence; 1985.
4. Branemark PI, Zarb G, Albrektsson ***T. Tissue-integrated prostheses: osseointegration in clinical dentistry. Special Edition for Nobelpharma***. Chicago: Quintessence; 1987. p. 268-71
5. Binnon PP. Evaluation of machining accuracy and consistency of selected implants, standard abutments and laboratory analogs. ***Int. J. Prosthodont***. 1995; 8: 162-78
6. Byrne D, Jacobs S, o'Connel B, Houston F, Claffey N. Preloads generated with repeated tightening in three types of screws used in dental implant assemblies. ***J Prosthodont***. 2006 May-Jun;15(3):164-71
7. Cox JF, Zarb GA. The longitudinal clinical efficacy of osseointegrated dental implants: a 3-year report. ***Int J Oral Maxillofac Implants*** 2001; 10: 303-11.
8. Cibirka RM, Nelson, SK, Lang, BR, Rueggeberg FA. Examination of the implant-abutment interface after fatigue testing. ***J. Prosthet. Dent***. 2001; 85: 268-75
9. Goodacre CJ, Kan JYK, Rungcharassaeng K Clinical complications of osseointegrated implants. ***J Prosth Dent*** 1999; 81: 537-552.

10. Hecker DM, Eckert ES.Cyclic loading of implat-supported prostheses: Changes in component fit over time. ***J. Prosthet. Dent***. 2003; 89: 346-51.

11. Hemmings KW, Schmitt A, Zarb GA. Complications and maintenance requirements for fixed for fixed prostheses and overdentures in the edentulous mandible: a 5-year report. ***Int J Oral Maxillofac Implants*** 1994; 9: 191-6.

12. Jemt, T. Failures and complications in 391 consecutively inserted fixed prostheses supported by Branemark implants in edentulous jaws: a study of treatment from the time of prosthesis placement to the first annual checkup. ***Int. J. Oral Maxillofac Implants*** 1991; 6:270-6

13. Lee J, Kim YS, Kim CW, Han JS. Wave analysis of implant screw loosening using an air cylindral cyclic loading device. ***J Prosth Dent*** 2002;88:402-8.

14. Lekholm U, Gunne J, Henry P, Higuchi K, Linden U, Bergstrom C, et al. Survivla of the Branemark implant in partially edentulous jaws: a 10-year prospective multicenter study. ***Int J Oral Maxillofac Implants*** 1999; 14: 639-45.

15. Marchack CB. A custom titanium abutment for the anterior single-tooth implant. ***J. Prosthet. Dent***. 1996; 76:288-91

16. Rangert B, Jemt T, Journeus L. Forces and moments on Branemark implants. ***Int. J. Oral Maxillofac Implants***. 1989; 4:241-7

17. Renouard F, Rangert B. ***Fatores de risco no tratamento com implantes: evolução clkínica e conduta***. 2001; Ed. Quintessence, 176 p

18. Rubenstein JE, Ma T. Comparison of interface relationships between implant components for laser-welded titanium frameworks and standard cast frameworks. ***Int. J. Oral Maxillofac. Implants*** 1999; 14: 491-5.

19. Sendyk CL. ***Distribuição das tensões nos implantes osseointegrados. Análise não linear em função do diâmetro do implante e do material da coroa protética.*** Tese de doutoramento. Fac. Odontologia da USP, São Paulo, 1998.

20. Sethi A, Kaus T, Sochor P, Axmann-Krcmar D, Chanavaz M. Evolution of the concept of angulated abutments in implant dentistry: 14-year clinical data. ***Impl. Dent***. 2002:11(1):41-50

21. Shigley JE, Mischke CR. ***Standard Handbook of Machine Design***: McGraw Hill, 1986: 23-26.

22. Wie H. Registration of localization, occlusion and occluding materials for failing screw joints n the Branemark system. ***Clin Oral Implants Res*** 1995; 6:47-53.

APÊNDICE

Figura 1: matriz metálica usada para confeccionar as coroas em resina acrílica

Figura 2: Vista oclusal de uma das coroas utilizadas no experimento

Figura 3: foto que mostra os parafusos avaliados e o intermediário Estheticone angulado

Figura 4: máquina de fadiga ERFOP 10, Erios, São Paulo, Brasil

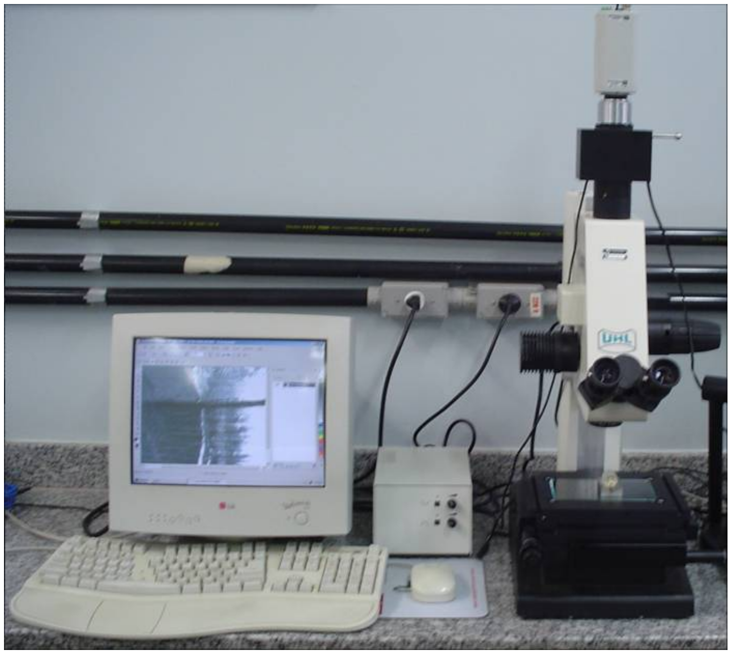

Figura 5: Microscópio digital de medida Walter Uhl, Asslar, Alemanha

Figura 6: corpo de prova no momento do destorque do parafuso protético