SERVIÇO PÚBLICO FEDERAL
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PROGRAMA DE PÓS GRADUAÇÃO EM ODONTOLOGIA

FREDERICK KHALIL KARAM

Comportamento mecânico de implantes cone Morse com conicidade interna em 16°

Mechanical behavior of Morse taper implants with 16° internal taper.

Tese apresentada à Faculdade de Odontologia da Universidade Federal de Uberlândia, como requisito parcial, para obtenção do Título de Doutor em Odontologia na área de Concentração Clínica Odontológica Integrada

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Orientador: Prof. Dr. Flávio Domingues das Neves

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Uberlândia, 2020

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

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SUMÁRIO

RESUMO

Este trabalho objetivou avaliar a influência da conicidade interna (11,5° e 16°) na interface pilar/implante e no comportamento mecânico de específicos implantes cone Morse. Dessa forma, este trabalho foi divido em três capítulos com diferentes objetivos. No capítulo 1 foi analisado o comportamento mecânico de implantes dentários com angulação de cone em 11,5° e 16° e seus respectivos pilares em titânio, por meio de Análise de Elementos Finitos (AEF) e teste de fadiga, seguindo as normas ISO 14801. Cinquenta e quatro implantes tipo cone Morse foram divididos em seis grupos, variando para os diversos implantes: conexão e macrogeometria externa. Foram realizados os testes computacionais para distribuição de tensão (AEF) e em sequencia os testes de fadiga, seguindo as normas ISO 14801. Os resultados apresentados demonstram que independente da macrogeometria externa dos implantes, o sistema com 16° de inclinação interna de cone foi mais resistente quando comparado ao grupo com 11,5°. No capítulo dois, foi realizado teste de resistência a fratura e padrão de falhas por meio de microscópio óptico. Vinte implantes com seus respectivos componentes protéticos foram divididos em 2 grupos, variando apenas o ângulo de conicidade interna. Os implantes foram fixados à uma estativa metálica e submetidos ao teste de resistência à fratura numa máquina universal de testes mecânicos. Em seguida foi realizada avaliação para determinar o padrão de falha das amostras. Os resultados apontam que o sistema com 16° foi estatisticamente mais resistente quando comparado ao sistema com 11.5°. Além disso, as amostras do grupo com 16° tendem a deformar na região cervical, enquanto as amostras com 11.5° tendem a fraturar no terço médio. No terceiro capítulo, foi realizado a avaliação do espaço microscópico existente entre o corpo do implante e o corpo do componente (interface P/I) comparando implantes de conicidades diferentes (11,5° e 16°), por meio de microtomografia computadorizada e microinfiltração com azul de toluidina. Dezesseis implantes com ápice perfurado e seus respectivos componentes protéticos instalados foram divididos em dois grupos, variando o ângulo de conicidade interna (11,5° e 16°). Estes implantes foram

instalados em tubos plásticos. Com auxílio de equipamento específico, foi aplicado azul de toluidina no ápice dos implantes e posteriormente aplicado 2 bahr de pressão por um período de 60 minutos. Após o teste, as amostras foram submetidas a microtomografia computadorizada a fim de avaliar se havia algum espaço microscópico entre componente protético e implante. Não foi possível observar azul de toluidina extravasando pela região pilar e implante e não foi possível encontrar nenhuma imagem que sugerisse espaço microscópico entre implante e componente protético na tomografia computadorizada. Graças aos resultados apresentados pelos capítulos supracitados, conclui-se que o sistema de implantes com conicidade interna em 16°, apresenta uma maior resistência quando comparado aos implantes de 11,5°, independente da macrogeometria. Além disso, independente da inclinação das paredes dos implantes cone Morse, não se observa desajustes entre o componente protético e os implantes.

Palavras-chave: implantes cone Morse, comportamento biomecânico, testes biomecânicos.

ABSTRACT

The aim of this study was answering some questions related to specific dental implants with Morse taper prosthetic connection. The main objective was to evaluate and compare the influence of inclination of internal taper (11.5° and 16°) on the abutment/implant interface and on the mechanical behavior of specific Morse taper implants. Thus, this study was didactically divided into three different chapters for the specific objectives. In Chapter 1, the mechanical behavior of 11.5° and 16° internal taper inclination and their respective titanium abutments was analyzed by Finite Element Analysis (FEA) and fatigue testing, following ISO 14801 standard. Fifty-four Morse taper implants were divided into six groups, varying implant, connection and macrogeometry. The computational tests for stress distribution (FEA) were performed and, then, the fatigue tests following the ISO 14801 standard. The results showed that independent of the macrogeometry of the implants, the system with 16° internal taper inclination was more resistant. In Chapter 2, fracture resistance and failure pattern tests were performed using a specific methodology. Twenty implants with their respective prosthetic abutments were divided into 2 groups, varying only the internal taper inclination. Subsequently, the implants were fixed, and the bending test was performed in a universal mechanical testing machine. Finally, the evaluation was performed to determine the failure pattern of the samples. The results indicate that the 16° system was statistically stronger when compared to the 11.5° system. In addition, samples from the 16° group tend to deform in the cervical region, while 11.5° samples tend to fracture in the middle third. In the third and last Chapter, the microscopic space between the interface implant/abutment was analyzed by comparing implants of different internal taper inclination (11.5° and 16°) using computed microtomography and microleakage with toluidine blue. Sixteen implants with open apex and their respective prosthetic abutments were divided into two groups, varying only the inclination of internal taper between them (11.5° and 16°) and installed in plastic tubes. Using a specific equipment developed by group, toluidine blue was applied to the apex of the implants and subsequently applied 2 bahr of pressure for 60

minutes. After the test, the samples were submitted to computed microtomography in order to evaluate if there was any microscopic space between the prosthetic abutment and the implant. It was not possible to observe toluidine blue extravasating the peri-implant region and could not find any image that would suggest microscopic space between implant and prosthetic abutment on computed tomography. Due to the results presented by the above chapters, it can be concluded that the 16° internal taper implant system has a higher resistance compared to 11.5° implants, regardless of macrogeometry. In addition, no microgaps was observed between the prosthetic abutment and implants in both systems studied, thus maintaining the biological sealing.
KeyWords: Morse taper implants, biomechanical behavior, biomechanical tests

1. INTRODUÇÃO E REFERENCIAL TEÓRICO

Os implantes originalmente desenvolvidos por Brånemark possuíam o desenho hexagonal externo na plataforma. Essa plataforma desempenhava a função de auxiliar na instalação cirúrgica dos implantes e unir o pilar protético ao próprio implante. Este tipo de junção, segundo estudo clínico para avaliação dos índices de sucesso de implantes, verificou uma perda óssea ao seu redor considerada normal, de aproximadamente 1,0 mm no primeiro ano em função e menos de 0,2 mm após o primeiro ano (Albrekson et al., 1986). Como inicialmente os implantes dentários haviam sido desenvolvidos apenas para desdentados totais, essa perda óssea fisiológica era pouco importante clinicamente. Entretanto, com a evolução da implantodontia para casos parciais e unitários, principalmente quando em área estética, essa perda óssea passou a ter grande significado clínico, uma vez que poderia significar a perda de uma papila interdental de um dente anterior. A manutenção óssea da região perimplantar é motivo de grande discussão na literatura e está relacionada a aspectos microbiológicos e biomecânicos, ambos relacionados à junção pilar/implante (P/I). O desajuste entre P/I tem sido indicado como um dos fatores causais das falhas protéticas (Quirynen et al., 1999) possivelmente pela diminuição do osso ao redor da plataforma do implante (Broggini et al., 2003; Broggini et al., 2006). O tipo de junção entre P/I está relacionado com o infiltrado bacteriológico e a presença de células inflamatórias que levam a perda óssea ao redor da microfenda existente na região da junção (Broggini et al., 2003; Broggini et al., 2006). Em meados de 2006 surge um novo conceito baseado no estudo de Richard J. Lazzara (Lazzara et al, 2006), que ao diminuir o diâmetro do pilar em relação ao diâmetro do implante, de maneira a distanciar-se da margem óssea, minimizou a perda óssea marginal. Esse conceito é explicado na Fig 1.

Figura 1 Lado direito da imagem observa-se o padrão até então utilizado para as junções de topo. Lado esquerdo da imagem, observa-se padrão plataforma switching. (Adaptado de Lazzara 2006).

Assim sendo, observou-se que seria benéfico aumentar a distância entre o componente protético e a crista óssea. Este conceito, como já descrito, foi denominado “plataforma switching”. Essa informação levou a análises das diversas junções P/I existentes no mercado, buscando-se a partir de então características especificas dos diversos desenhos que fossem favoráveis aos aspectos biológicos e biomecânicos. Entre os mais famosos comercialmente, o desenho da Ankylos era o mais favorável.

Basicamente, as junções que unem os implantes aos pilares, podem ser classificadas como de topo (hexágono externo - H.E., hexágono interno - H.I., Nobel Replace, entre centenas de outros) e cone Morse (Ankylos, Straumann, Astra e Bicon, entre centenas de outros). Estes últimos basearam-se em um desenho, muito utilizado na engenharia mecânica, influenciada pelos trabalhos de Stephen A. Morse e utilizados para componentes rotatórios de máquinas desde 1864. Há aproximadamente 25 anos, foi aplicada na implantodontia

contemporânea (Suter et al., 1993). Na implantodontia, a principal diferença da junção Morse, quando comparado às de topo, é o desenho cônico interno aos implantes, que faz com que a interface P/I independa apenas do parafuso para fixação e estabilização em função dos pilares. Isso produz uma melhor estabilidade, diminuindo os desapertos de parafuso, tão comuns nas outras plataformas (da Silva-Neto et al., 2017). Entretanto, nas junções Cone Morse existentes (mais comercialmente usadas), a Straumann e ASTRA, não atendiam ao conceito de plataforma switching e o Bicon, com uma proposta diferente e intrigante de contar apenas com o efeito Morse, foi pouco reproduzido.

Para garantir os efeitos benéficos desse tipo de sistema é importante que os implantes sejam capazes de resistir aos esforços mastigatórios. Para isso, foram realizados estudos para investigar o comportamento mecânico e biológico de implantes dentários com interface cônica interna. Em estudo recente, que teve como objetivo comparar implantes de hexágono externo com 3.75 mm de diâmetro, hexágono externo com 3.3 mm de diâmetro e implantes cone Morse de diâmetro 3.5 mm, aplicou-se carga no pilar, até o limite máximo de resistência do conjunto pilar implante. Concluiu-se que não houve diferença estatística na resistência de implantes HE com 3.75 mm de diâmetro com implantes CM de 3.5 mm de diâmetro (Carneiro et al., 2016). Entretanto, observa-se uma diminuição significativa na resistência dos implantes de 3.3 mm de diâmetro com plataforma de 3.4 mm. Sendo assim, na questão resistência, os implantes de diâmetro 3.5, junção cone Morse com 11,5° de conicidade interna, demonstram resistência semelhante aos implantes de 3.75 mm de diâmetro e junção H.E. Ressalta-se que os implantes HEs em questão fraturam em 0,2 % (Balshi et al., 1996). Por não haver desaperto de parafuso para junções do tipo cone Morse os problemas clínicos se concentram nas fraturas dos pilares e não no implante propriamente dito (Schwarz et al., 2000). Além disso, alguns fatores ligados a manufatura desses sistemas podem influenciar na resistência. Por exemplo a liga titânio utilizado com matéria prima e a conicidade interna das paredes da junção Morse. Uma vez que estes dois aspectos podem influenciar na espessura das paredes internas e externas dos

implantes. O estudo de Castro 2015 (Castro et al., 2015) avaliou a deformação cervical em diferentes diâmetros de implantes cone Morse e a deformação residual após a remoção do carregamento. Este estudo comprova que a espessura da parede do implante cone Morse influenciou a deformação das paredes internas e externas da região cervical. Entretanto, os diâmetros testados (3,5; 4,0 e 5,0 mm) demonstraram valores de deformação clinicamente aceitáveis. Dessa forma, os implantes com conexão cone Morse, passaram a ser uma opção para reabilitação de casos unitários, parciais e totais, apresentando algumas vantagens significativas.

Apesar das vantagens descritas, questões clínicas forçaram alterações de macrogeometria. Dessa maneira, buscando facilitar a indexação protética do sistema C.M. algumas empresas desenvolveram produtos com indexador geométrico no fim do cone interno do implante, que facilitaria a instalação dos implantes e o fluxo clínico laboratorial. O trabalho de Perriard et al 2002 e Dias et al 2015 investigaram a resistência à fratura e microinfiltração, respectivamente, de implantes com indexador e sem indexador e não encontraram diferenças estatísticas entre os grupos avaliados. Dessa forma, Empresas como Straumann, Ankylos e Neodent seguiram nesta linha para adequar seus implantes a esta demanda. Entretanto, novas questões apareceram. Para caso empresa Neodent a dificuldade com a chave de instalação dos implantes (área de contato chave-index interno muito justa), dificuldade na troca de pilares parafusos passantes (cujo imbricamento mecânico exige certa perícia no procedimento), dificuldade táctil na instalação de transferentes de moldagem e pilares. Estes problemas associados a casos de fraturas de componentes sinalizavam que os desenhos dos implantes ainda poderiam ser melhorados. Quanto a questão das fraturas, informações de fraturas de implantes de 3,5 e do corpo dos pilares parafusos passantes em área posterior, embora raras, apareciam, levando a empresa a desenvolver um kit resgate.

Por tudo isso, a empresa Neodent lança um novo implante, acreditando ser este, melhor que os implantes da linha CM. O chamado implante Grand Morse (GM). Entre as vantagens apresentadas pela empresa, algumas são

inquestionáveis: indexador protético desenhado sob a área de contato do cone interno, corrigindo a questão da chave de instalação e do fluxo clínico-laboratorial; componentes protéticos com auto remoção, facilitando as substituições de pilares quando necessário. Nas alterações propostas também ocorreu a inclinação das paredes do cone interno de 11,5° para 16°. Como consequência houve a alteração da espessura dos componentes parafusos passantes.

A fim de comprovar as vantagens apresentadas pela empresa, se fez necessário uma investigação aprofundada. A principal alteração foi a conicidade interna, objetivando a melhoria da resistência a fratura (fig.2). A matéria prima utilizada, já é conhecidamente biocompatível, resistente mecanicamente e não foi alterada. Sabe-se que a junção cone Morse da linha C.M. apresenta-se mais resistente quando compara as tradicionais H.E. este trabalho se justifica investigando o comportamento mecânicos dos implantes da linha G.M., comparando com os implantes da linha C.M. É importante ressaltar que os implantes Grand Morse e sua linha de componentes protéticos já estão aprovados na Anvisa, desde de janeiro de 2017.

Figura 2 Imagem de dois implantes. O implante á esquerda é um cone Morse de diâmetro de 3.5 da linha C.M. Já o implante a direita possui o mesmo diâmetro, entretanto com alteração da conicidade interna, implante GM.

Contudo, a influência de diferentes conicidades internas das junções cone Morse gerou ainda um outro questionamento: o aumento da inclinação de 11,5° do CM para 16° do GM, embora com maior área de contato pilar implante, manteriam o comportamento favorável dos implantes CM, em relação a perda óssea marginal? Uma vez que isso já era observado em trabalho de acompanhamento longitudinal. (Mangano et al., 2011). Resolveu-se assim comparar o grau de infiltração de duas angulações internas de implantes cone Morse em condições dinâmicas, correlacionando-os com uma possível alteração da interface durante este processo.

Diante disso o objetivo geral deste trabalho foi avaliar e comparar a influência da conicidade interna (11,5° e 16°) na interface pilar/implante e no comportamento mecânico de específicos implantes cone Morse. No capítulo um foi analisado o comportamento mecânico de implantes dentários com angulação de cone em 11,5° e 16° e seus respectivos pilares em titânio, por meio de Análise de Elementos Finitos (AEF) e teste de fadiga, seguindo as normas ISO 14801. No capítulo dois, foi realizado teste de resistência fratura e padrão de deformidade por meio de uma metodologia previamente realizada

pelo grupo. No terceiro capítulo, foi realizado a avaliação do espaço microscópico existente entre o corpo do implante e o corpo do componente (interface P/I) comparando implantes de conicidades diferentes (11,5° e 16°), por meio do microtomografia computadorizada e microinfiltração com azul de toluidina.

2. Capítulos

CAPÍTULO 2.1

Título: Mechanical performance of Morse taper implants: finite element analysis and fatigue test

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Original research article

Mechanical performance of Morse taper implants: finite element analysis and fatigue test

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Authors disclose any financial competing interests and any non-financial competing interests that may cause embarrassment if they became public after the publication of the manuscript.

ABSTRACT

Purpose: Compare two different morse taper implant/ abutment with internal taper (16° and 11.5°), of three different dental implant body (conical, cylinder and hybrid) to verify the difference on stress values due to the dissipation of occlusal loads and implant/abutment integrity, after Finite Element Analysis (FEA) and Fatigue test.

Materials & Methods: Fifty-four Morse taper implants were divided into 6 groups (n=9), depending on abutment/implant connection design and implant external design. Group 1 CM DRIVE, 2 GM DRIVE, 3 CM TITAMAX, 4 GM TITAMAX, 5 CM ALVIM and 6 GM HELIX. FEA and Fatigue test (N) were performed. All tested groups were modeled for FEA, simulating a polyacetal base with the installed implant was placed in an angled device of 40°. The Fatigue test was performed at the same conditions described above, and under cyclic loading tests, with a frequency of 15 Hz, according to the specifications of ISO 14801.

Results: FEA demonstrated more homogeneous stress distribution on 16° Morse taper implant. Statistically differences were observed, favoring 16° Morse taper implant, when comparing to 11.5° implant, independently of the external implant design. For Groups 1 x 2, 3 x 4 and 5 x 6, the mean value was 337.8N, 439.8N, 317.5N, 436.0N and 368.1N, 414.4

Respectively.

Conclusion: The implant/abutment morse taper design influenced on stress values and implant/abutment integrity, favoring the 16° Morse taper implant.

Keywords: implantology, implant/abutment integrity, stress distribution.

INTRODUCTION

One hundred and fifty years ago, in 1864, the Morse Taper concept was defined by Stephen A. Morse, an enterprising mechanic, who developed it to reliably join of two rotating machine components. More than 25 years ago, the Morse taper principle was applied in Oral Implantology.[1] When compared to butt joint interface, the tapered junction of Morse taper results in an excellent mechanical stability, large contact pressure and resulting frictional resistance between the implant and the abutment.[2,3] Morse taper system avoids micromoviments in the implant/abutment (I/A) interface contributing to a minimum inflammation level in the adjacent tissue and to a less crestal-bone loss adjacent to implant.[4] Still in mechanical scenario, a systematic review of mechanical behavior of different implant-abutment connection designs showed higher mechanical stability of tapered connection, reducing significantly prosthetic failures or complications.[5]

Morse taper junctions are preferable then external or internal hexagon interface. Less marginal bone loss,[6,7] minimal inflammation level in the implant/abutment interface[4] and mechanical behavior are more favorable in Morse taper junctions. Four types of junctions were primarily produced: Straumann (Straumann, Switzerland), Ankylos (Friadent GmbH, Mannheim,Germany), Bicon (Bicon Dental Implants, Boston, MA, USA) and Astra (Astra Tech AB, Molndal, Sweden). One difference observed between these implants is the internal taper degree. The Straumann demonstrate 16°,[8,9] Astra 11°,[8,9] Ankylos 11.5°[10] and Bicon 1.5°. Factors related to implants' manufacture could influence on resistance, such as: raw-material (for implant and abutment), implant external design and internal taper degree, which could influence on different thickness of the cervical wall of implants. A study[11] evaluated the deformation caused by compression in different diameters of Morse taper implants and the residual deformation after removal of the load, demonstrating that the diameter influenced the strain

around the internal and external walls of the cervical region of Morse taper implants. Furthermore, all diameters demonstrated clinically acceptable values of strain. Other studies that investigate mechanical behavior of implants did not considered internal taper degree;[12,13] when considering, the external geometry of the implant is not observed.[8,9] So, studies that compare different internal taper degree are rare.

Therefore, the aim of this study was to compare two different implant/ abutment internal taper (16° and 11.5°), of three different external design implants to verify the difference on stress values and implant/abutment integrity, after Finite Element Analyses (FEA) and Fatigue test. The null hypothesis was that there were no difference on stress values and implant/abutment integrity, after oblique loading.

MATERIAL AND METHODS

Finite Element Method

Original 3D CAD models of each group item, provided by the manufacturer (Neodent, Curitiba, Brazil) were CAD models used were assembled in Autodesk Inventor software before exporting to CAE (Computer Aided Engineering) software "FEMAP Siemens". The following items were considered in the assembly: hemispherical body, prosthetic abutment, screw, implant and polyacetal block as shown below. The assembly of the parts was based on ISO 14801 standard that is used for compressive testing of dental implants. Some information relevant to the assembly is: the hemispherical body must be modeled considering the distance of 8 mm between the base of the implant and the center of the sphere, the implant must be maintained 3 mm exposed in relation to the polyacetal base and the screw thread must be positioned without interference (Figure 1).

After the samples were assembled, the exporting of the CAD models to CAE software (FEMAP Siemens, Berlin-Charlottenburg, HRB 12300 Munich, HRB 6684) were done by Parasolid".X_T" extension. The CAD geometry was initially imported into FEMAP, and the boundary conditions (loads and constraints) were defined. Subsequently, the materials with their

respective mechanical properties were defined by the manufacturer (Neodent, Curitiba, Brazil), according to Table 1.

For the polyacetal block, the Young's Modulus of 3 GPa was assumed, according to the recommendation of ISO 14801 for fatigue tests. Ten-node tetrahedral elements were used to perform the analysis, since the implants geometries were relatively complex with many radius, chamfers and threads, making it impossible to reach good results using other elements. The size of the element was chosen and refined in the regions of interest. After the generated mesh, its quality was evaluated using the Aspect Ration criteria.

The corresponding contact pairs and friction coefficient between the surfaces were defined: "glued" contacts between the implant-polyacetal and abutment-hemispherical body interfaces and frictional contacts between the implant-abutment, implant-screw and screw-abutment pairs. The value of 0.57 was considered for the friction coefficients.

After the contact pairs were defined, the fixation regions of the model were defined as the lateral of the polyacetal. This item is analogous for all groups studied. The tightening torque can be related to the preload from the following equation:[14]

The tightening torque of the screw was replaced by the preload value, calculated from Equation 1. A preload of 117 N was applied to the 11.5 º screw (relative to a torque of 15 N.cm) and 203 N for the 16º screw (relative to a torque of 20 N.cm). An oblique force of 150 N at 30° from the axis of the implant was applied according to ISO 14801.

The analysis of the results presented was performed considering the Maximum Principal Stress criterion (failure criteria), considering both interfaces (16° and 11.5°).

Fatigue test

Nine specimens were defined for sample number for each group, according to standard ISO 14801 (Table 2). The standard establishes that at least four different loads must be tested. A maximum load, for which 3 specimens must withstand 5 million cycles without failure, and at

least 3 subsequent loads to the maximum load, with at least 2 specimens for each load. The tested groups and combinations are described below:

- Group 1 X Group 2
- Group 3 X Group 4
- Group 5 X Group 6

The tests were performed in a dry environment with temperature of 20 ± 5°C. Each implant was installed with a torque of 60 N.cm in a polyacetal base, 3 mm above the bone level, simulating severe bone loss. The polyacetal base was placed in an angled device of 40° (Figure 2) for fixing at a dynamic testing machine (Instron model E3000 machine, Instron, United Kingdon). The frequency used in the test was 15 Hz. Static compression test was performed. The collected data were grouped and analyzed using the Test T-Student ($\alpha = 0.05$).

RESULTS

The 16º morse taper presented a more homogenous distribution of the stress in all the macrostructres tested compared wit the 11,5º connection. When comparing Group 1,3 and 5 versus Group 2,4 and the FEA demonstrated that the stress distribution is more homogeneous in 16º morse taper implant.

In fatigue test, implants were submitted to fatigue until fracture. The results can be showed on table 3.

DISCUSSION

The aim of this study was to compare two different implant/ abutment internal taper (16° and 11.5°), of different external design implants to verify the difference on stress values and implant/abutment integrity, after Finite Element Analyses (FEA) and Fatigue test. So, the null hypothesis of this study was rejected, since there was a statistical difference between both different implant/ abutment internal taper (16° and 11.5°), independently of external design implants. FEA and Fatigue test were used, and there both methodologies presented difference.

The implant/ abutment internal taper of 16° demonstrated better stress distribution and more favorable mechanical results.

Different factors could cause marginal bone loss in implants, and could be related to stress distribution in the implant.[5-7] In Morse taper implants, the distribution of stress resulting from axial loads is distant from the cervical region and the stress is distributed in the middle portion of the implants. In the present study, the implant/abutment internal taper of 16° exhibited more favorable stress distribution (Figures 3, 5 and 7). This result suggests that Morse taper implants with major values of implant/ abutment internal taper could favor bone loss maintenance. Meanwhile, the distance between the implant/abutment interfaces could interfere in implant bone loss. In internal taper of 16° the distance between this interface and the periimplantar bone is larger when comparing to internal taper of 11.5°. The same condition happens when comparing narrow implants (3.5mm) with standard implants.[15] The authors of the present study could not prove the balance between both information, and focused on mechanical characteristics of the tested implants; also, future clinical trials could be performed to understand this point.

It is very important to test if the differences in implant/ abutment internal taper influence on implants' resistance, resisting to masticatory efforts. Morse taper implants (11.5°) are more resistant than External Hexagon implants.[12] The results of the fatigue test demonstrated that implants with 16° of implant/abutment internal taper are more resistant then implants with 11.5° of implant/abutment internal taper, although with the same diameter (tables 3, 4 and 5).

Despite the implants with 16° of implant/abutment internal taper has 30% less titanium thickness when comparing to implants with 11,5. The 16° of implant/abutment internal taper, the demonstrated to be more resistant than the first one. Connecting the abutment to the implant could compensate this variation on thickness. Apparently, the higher resistance presented by the abutment could reinforce the implant/abutment system. Another aspect that must be discussed is: higher the resistance to fracture of the abutment, higher the risk of implant's fracture. The

diameter of the abutment in implants with 16° of implant/abutment internal taper is larger than the abutment in implants with 11.5° of implant/abutment internal taper. However, clinical reports of fractures in Morse taper implants are rare, independently of the inclination of implant/abutment internal taper.

CONCLUSION

According to the present study, the implant/abutment internal taper influenced on stress values and implant/abutment integrity, favoring the 16° Morse taper implant.

ACKNOWLEDGEMENTS

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FIGURES

Figure 1: Sample assembled: A- Polyacetal, B- Implant, C- Screw, D- Abutment e E- Hemispherical body.

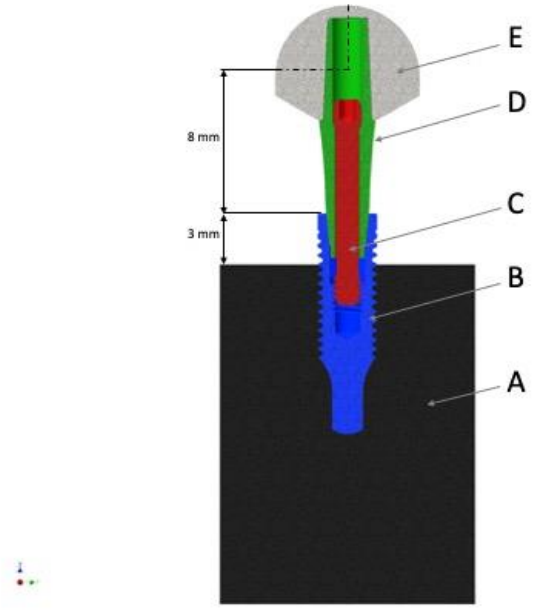


Figure 2: Fatigue testing set up.

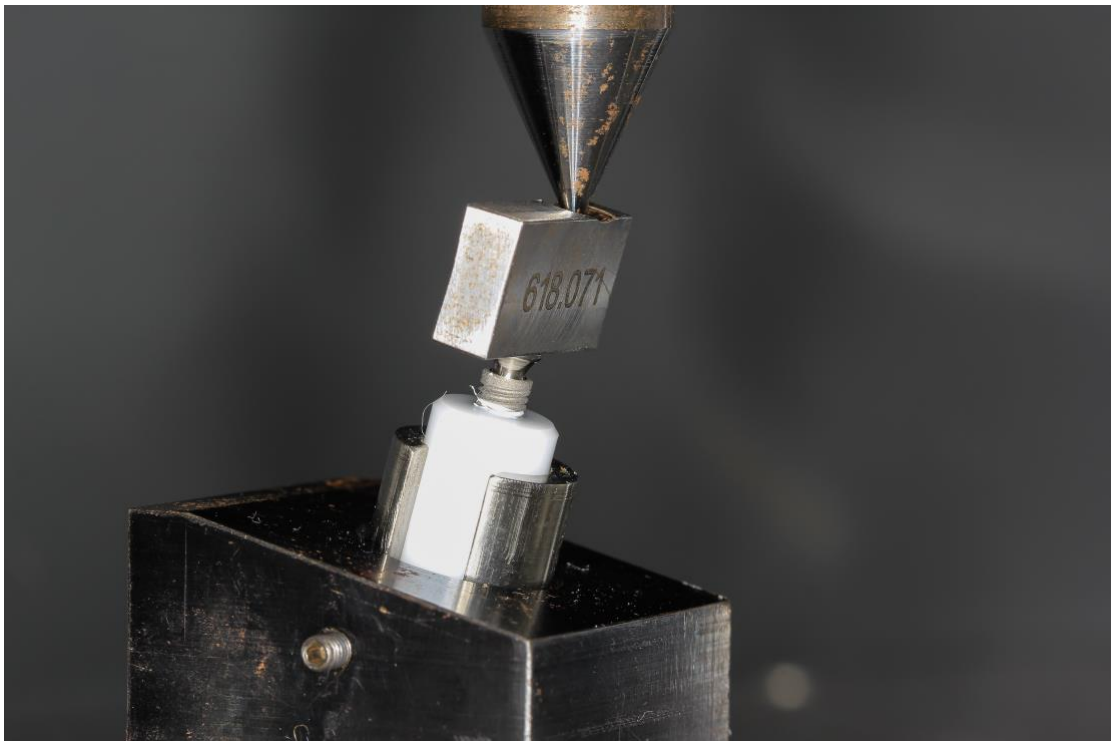


Figure 3: FEA (A: CM Drive implant, B: GM Drive implant).

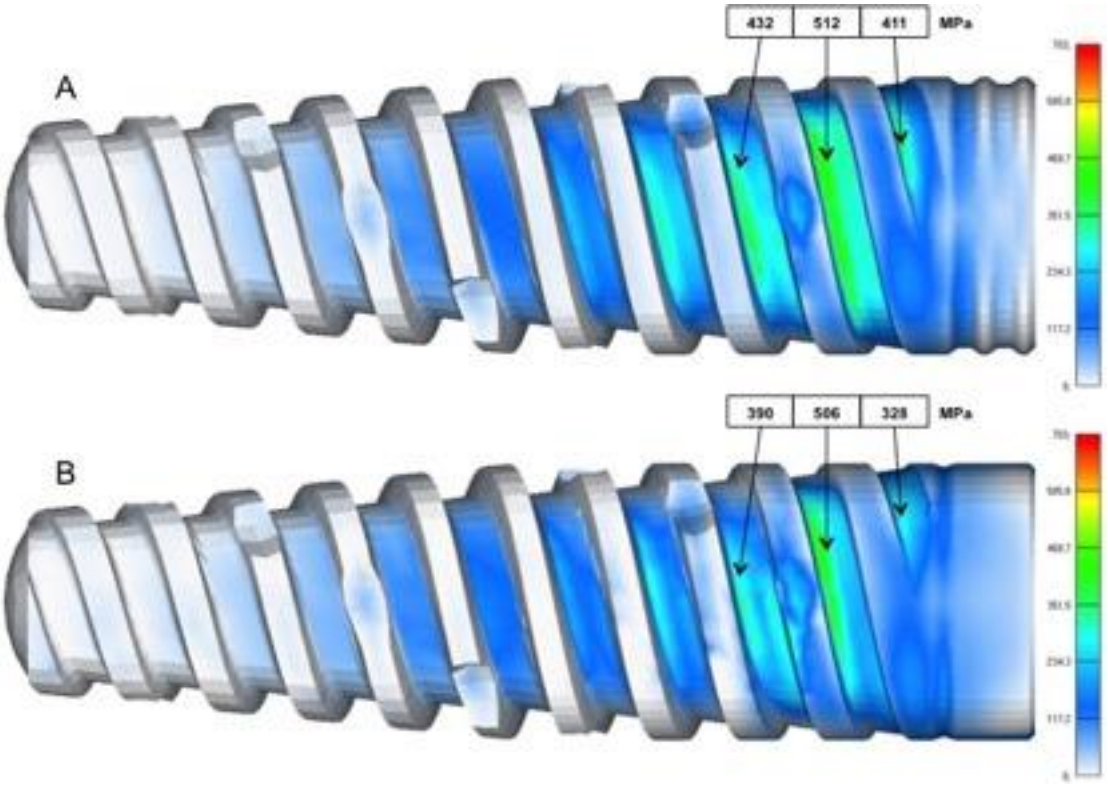


Figure 4: Load Values (N) x Cycles (n°) between CM Drive and GM Drive implant.

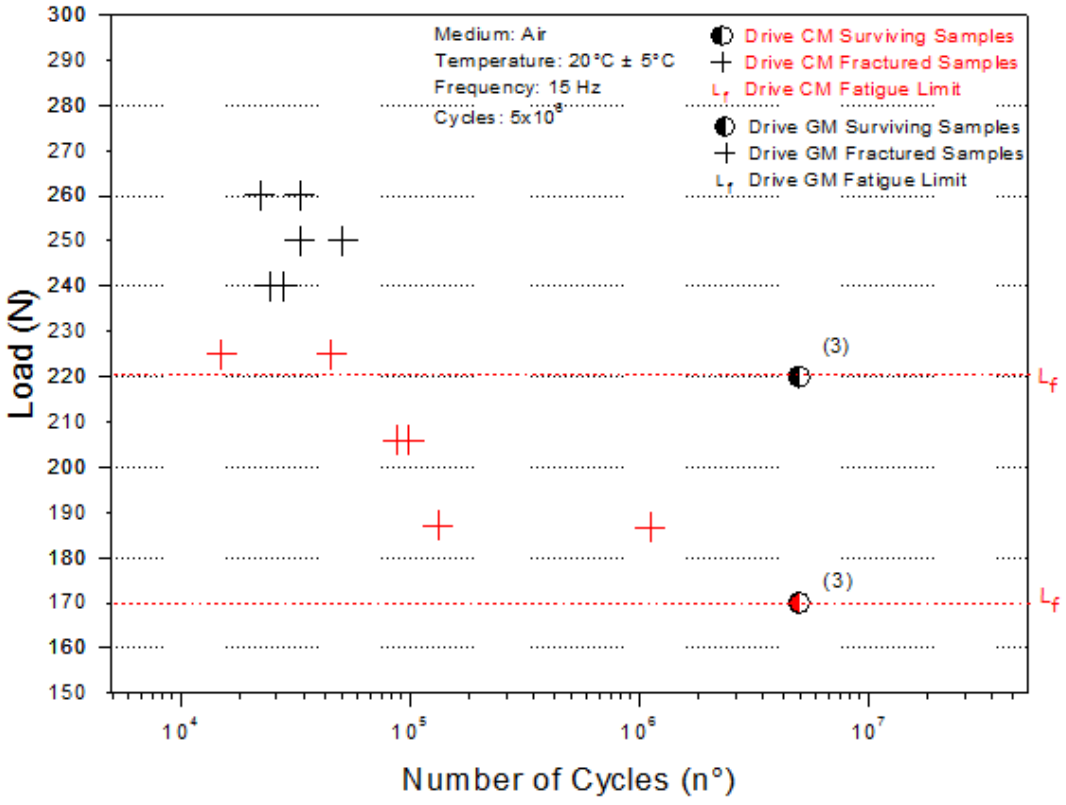


Figure 5: FEA (A: CM Titamax implant, B: GM Titamax implant).

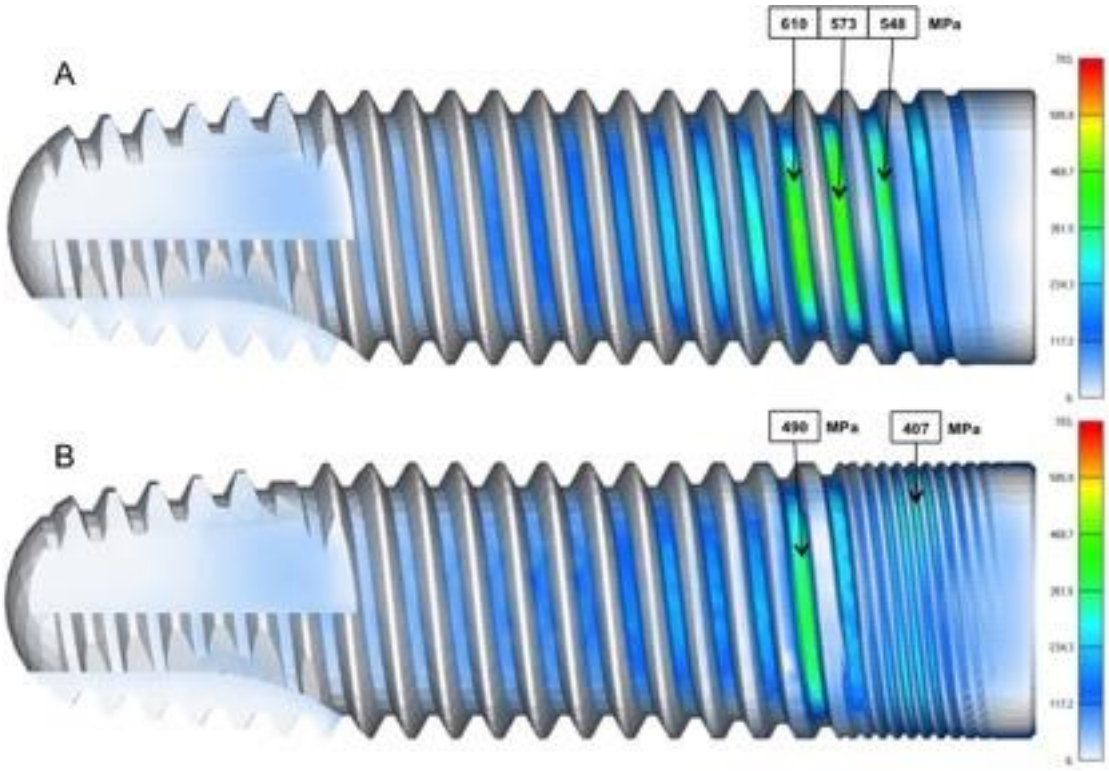


Figure 6: Load Values (N) x Cycles (n°) between CM Titamax and GM Titamax implant.

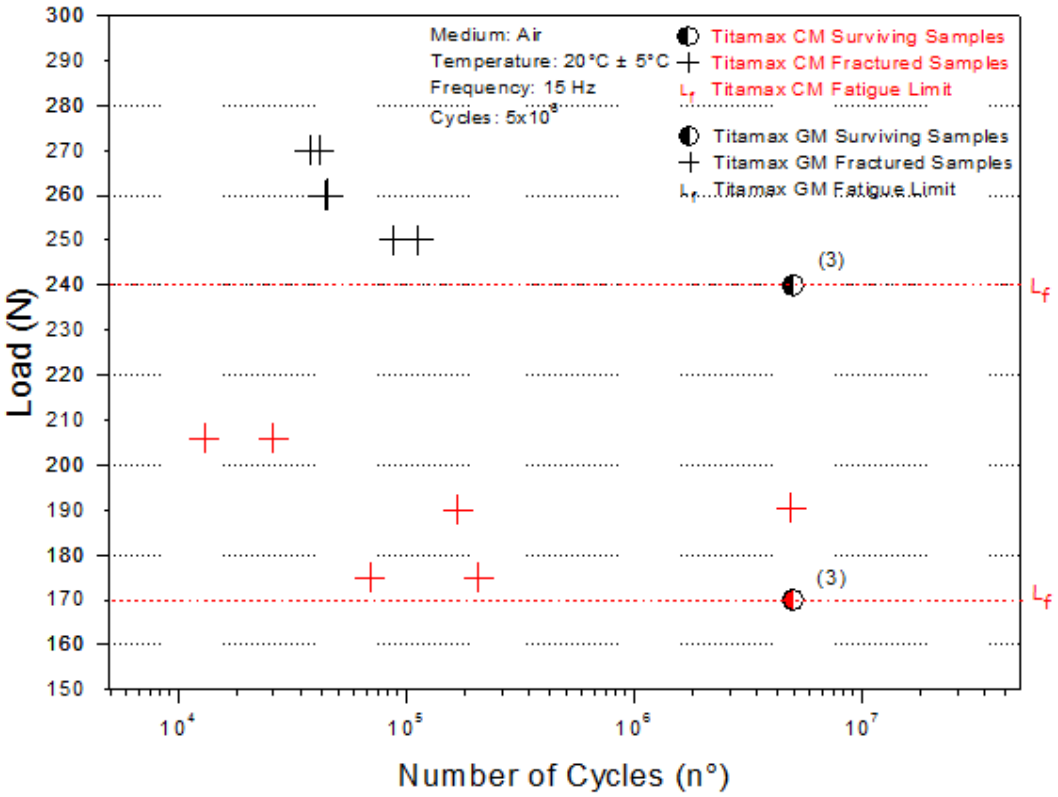


Figure 7: FEA (A: CM Alvim implant, B: GM Helix implant).

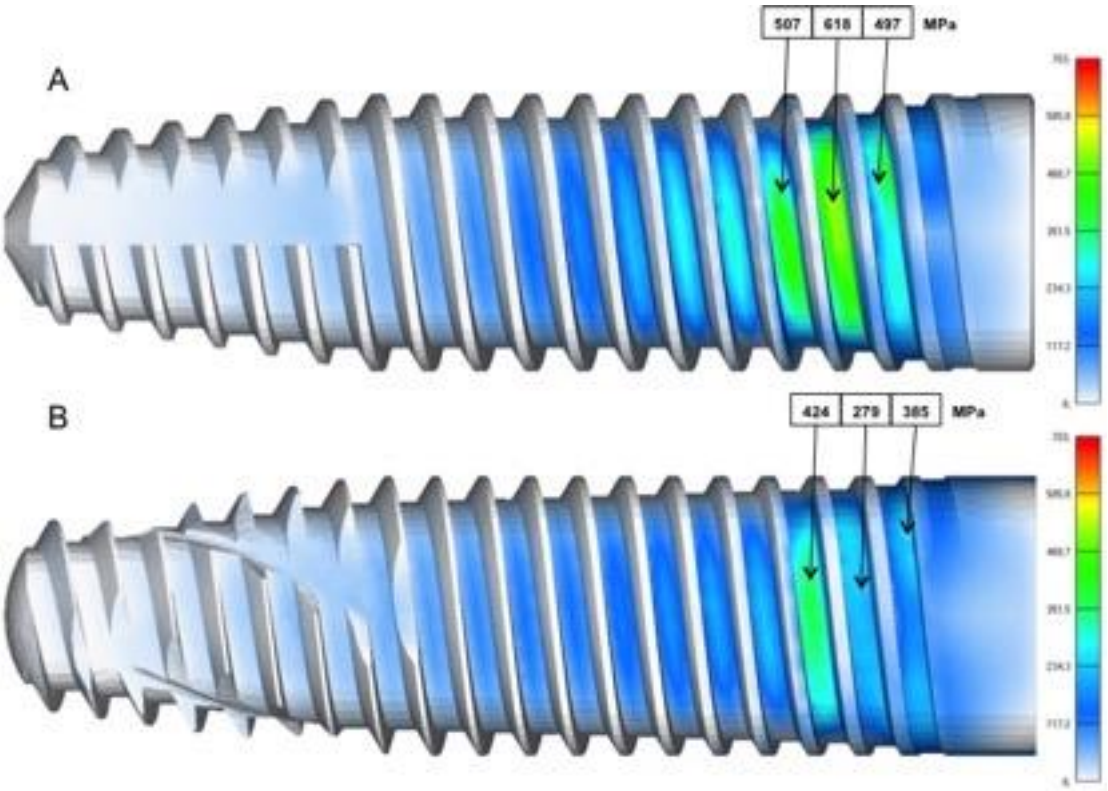
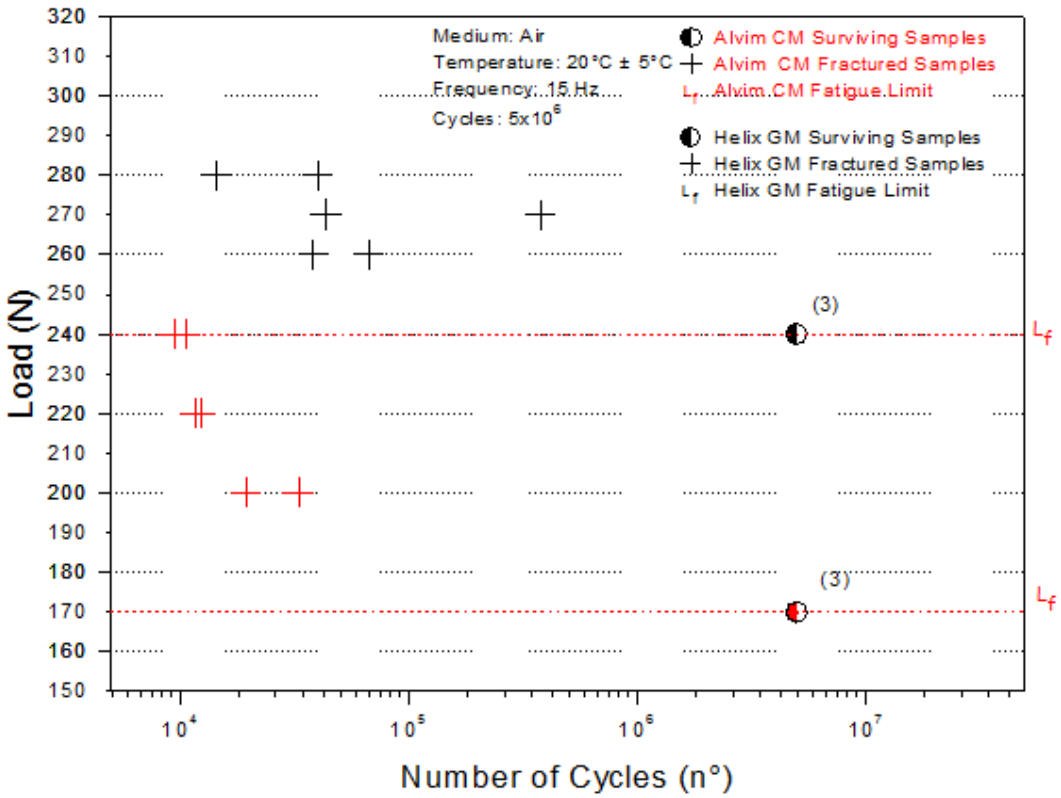


Figure 8: Load Values (N) x Cycles (n°) between Alvim and Helix implant.



TABLES

Table 1 - Mechanical properties of tested materials.

Description	Material	Young's modulus (MPa)	Poisson coefficient
CM Titamax Implant 3.5x13	Titanium Grade 4	105000	0,361
GM Titamax Implant 3.5x13	Titanium Grade 4	105000	0,361
CM Drive Implant 3.5x13	Titanium Grade 4	105000	0,361
GM Drive Implant 3.5x13	Titanium Grade 4	105000	0,361
CM Exact Universal Abutment 3.3x6x5.5	Titanium alloy Ti6Al4V-ELI	105000	0,361
Long Screw CM Universal Abutment	Titanium alloy Ti6Al4V-ELI	105000	0,361
Hemispherical Body CM Universal Abutment	Titanium alloy Ti6Al4V-ELI	105000	0,361
GM Exact Click Universal Abutment 3.3x6x5.5	Titanium alloy Ti6Al4V-ELI	105000	0,361
Screw GM Abutment	Titanium alloy Ti6Al4V-ELI	105000	0,361
Hemispherical Body GM Universal Abutment	Titanium alloy Ti6Al4V-ELI	105000	0,361

Table 2: Materials description.

Group	Description	Number of samples	Lot
1	CM Drive Implant (3.5x13)	9	800.136.493
1	CM Exact Universal Abutment 30° (3.3x6x3.5)	9	800.011.231
1	CM Pass-through Screw Universal Abutment	9	800.146.045
2	GM Drive Acqua Implant (3.5x13)	9	800.109.846
2	GM Exact Click Universal Abutment 30° (3.3x6x3.5)	9	800.117.176
2	GM Screw Abutment (1.75x10.75)	9	800.075.048
3	CM Titamax Implant (3.5x13)	9	800.206.881
3	CM Exact Universal Abutment 30° (3.3x6x3.5)	9	800.007.292
3	CM Pass-through Screw Universal Abutment	9	800.104.795
4	GM Titamax Acqua Implant (3.5x13)	9	800.109.693
4	GM Exact Click Universal Abutment 30° (3.3x6x3.5)	9	800.117.176
4	GM Screw Abutment (1.75x10.75)	9	800.075.048
5	CM Alvim Implant (3.5x13)	9	800.196.433
5	CM Exact Universal Abutment 30° (3.3x6x3.5)	9	800.191.811
5	CM Pass-through Screw Universal Abutment	9	800.104.795
6	GM Helix Acqua Implant (3.5x13)	9	800.109.867
6	GM Exact Click Universal Abutment 30° (3.3x6x3.5)	9	800.117.176
6	GM Screw Abutment (1.75x10.75)	9	800.075.048
-	Hemispheric body Abutment Universal Angled CM 17°/30° 3.3x6x3.5	54	800.109.765
-	Angled Base Device 40°	1	N/A

Table 3: Values obtained in static compression test.

Sample	Maximum Load (N)					
	CM Titamax	GM Titamax	CM Drive	GM Drive	CM Alvim	GM Helix
1	307.5	442.1	377.8	443.8	370.9	449.4
2	327.0	420.1	384.0	438.7	366.4	430.3
3	317.9	445.9	362.4	436.9	368.1	414.5
Mean value	317.5 B	436.0 A	374.7 B	439.8 A	368.5 B	431.4 A
Standard Deviation	9.8	13.9	11.1	3.6	2.3	17.5

CAPÍTULO 2.2

Frederick Khalil Karam, Karla Zancopé, Flávio Domingues das Neves. Influence of internal taper angle on fracture resistance of Morse taper dental implants. The International Journal of Oral & Maxillofacial Implants.

Influence of internal taper angle on fracture resistance of Morse taper dental implants

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Abstract

Purpose: Some factors may influence on Morse taper implants resistance, as the titanium alloy used as raw material and the internal taper of the Morse junction walls. The aim of this study was to evaluate the fracture resistance of two types of Morse taper implants with different internal taper angles by bending test and deformation pattern.

Materials and methods: Twenty conical Morse taper implants (Neodent) were divided in 2 groups (n=10): GM (16° implant/abutment); CM (11.5° implant/abutment). Fracture resistance (N) was determined by force application of a perpendicular load to the abutments with a universal testing machine. The statistical analyses was performed using Test T-Student. (a=0.5). To analyze the deformation pattern, the samples were submitted to microscopic evaluation.

Results: Statistical difference was found between the GM and CM groups. Mean fracture resistances were 605 N for group GM and 431 N for group CM. The groups evaluated presented a different deformation pattern.

Conclusion: The internal taper influence on fracture resistance of Morse taper dental implants

INTRODUCTION

The implant joints that connect the implants to the prostheses can be classified as external hexagon, internal hexagon and Morse Taper. The latter was based on a design by Stephen A. Morse, already used for rotating machine components since 1864. Approximately 25 years ago, it was applied in contemporary implantology[1]. If the internal taper angle is 2° to 8°, the connection is called a Morse taper connection[1]. The Morse taper implants were inserted on dentistry to increase the prosthetic stability at the implant/abutment interface (I/A), to decrease the effects of initial bone loss [2,3], to reduce the risk of screw loosening and avoid the presence of a gap in the I/A interface.[4-7] This prosthetic connection type has an internal junction that presents friction and mechanical imbrications, which decreases I/A interface gap.[8-10] This characteristic associated with the preload abutment-implant interface and occlusive forces is essential for this system stability,[11,12] predicting the rehabilitation behavior[13]

Some factors may influence on Morse taper implants resistance, as the titanium alloy used as raw material and the internal taper of the Morse junction walls. The thickness of the external wall of the cervical region and the thickness of the prosthetic component is related to how many degrees the internal taper angle of the implant has. For example, considering the 3.5mm diameter implant, the greater the contact angle inclination, the thinner the implant wall and the thicker the diameter of the prosthetic component. Few studies in literature investigate the influence of that factor on the fracture resistance of those implants. A study evaluated the amount of deformation form compression

caused by different diameters of Morse taper implants and the residual deformation after load removal.[14] This study showed that the thickness of Morse taper implant wall influenced the deformation of the internal and external walls of the cervical region. However, the diameters tested (3.5, 4.0 and 5.0 mm) demonstrated clinically acceptable deformation values in implants with contact angle of 11.5º.

Even with the previously mentioned studies, clinical reports still show fractures in implants and abutments.[15] Therefore, the aim of this study was to evaluate the fracture resistance of two types of Morse taper implants with different internal taper angles by bending test and deformation pattern.

MATERIALS AND METHODS

Twenty Morse taper implants (Neodent) were divided in 2 groups (n=10): GM (16° implant/abutment); CM (11.5° implant/abutment) described on Table 1.

Sample Preparation

The implants were positioned into a metallic holder, to receive loads at an angle of 90 degrees relative to the long axis. The implant shoulder was also positioned 4mm above the metallic holder, to isolate the prosthetic index and simulate marginal bone crest resorption. A metallic instrument was used to confirm this distance. The implant was then fixed to the metallic base with a

screw, and the abutment was installed over the implants, according to manufacturer's torque recommendation. (Fig 1)

Bending Test

The implant and the metallic holder were fixed on the mechanical testing machine (EMIC; 2000DL) and a stainless-steel spherical point (4 mm diameter) connected to a load cell of 500 KN capacity (KN500; EMIC) was used to load the samples (Fig. 1). The universal testing machine applied the bending load at a crosshead speed of 0.5 mm/min. A computer mounted through association in the machine was programmed to interrupt the test cycle process for an upper 5.0 mm displacement or an abrupt strength decrease of the tested material. The load was applied at 2 mm of the abutment platform.

After each mechanical testing, the alignment of the stainless-steel spherical point was conferred. The computer coupled to the load cell was programmed to record the force (N) during flexion of the implant/ abutment versus displacement (mm) into graphics.

Deformation Pattern

To analyze the deformation pattern, the samples were submitted to microscopic evaluation. Initially, 5 faces were standardized in each sample. Each of the faces were analyzed by a stereomicroscope (Leica MS5),

accompanied by a secondary camera (AxioCam ERc 5S). The images were exported and were computed with the aid of a software. (AxioVision). Thus, it was possible to determine in all samples standardized faces, producing so standardized images, making possible to evaluate a deformation pattern. (Fig. 3, Fig. 4)

Statistical Analyses

The statistical analysis of the fracture resistance data was performed using the Test – T student, significant difference test (a=.05). All analyses were performed with a statistical software (Sigma Plot version 12.0; Systat Software Inc.). The deformation pattern was analyzed descriptively.

RESULTS

The mean and standard deviation values are described in table 2. Statistical difference was found between the GM and CM groups. The internal taper inclination was determinant for more resistance in the GM group when compared to the CM group. The minimum and maximum displacements of all tested groups were presented on Scatter Plot Column Mean. (Fig 2)

The groups evaluated presented a different deformation pattern. In the CM group, a marked displacement was observed in the middle third, presenting a deformation pattern involving ¾ of the implant circumference. At the GM

group, a marked deformation was observed in the cervical third and an axial view shows a gap between abutment and implant, showing no fracture in its entire body.

DISCUSSION

The presented study aimed to evaluate the influence of the internal taper angle of two type of Morse taper implants. In the GM group, implants with 16º of internal inclination were evaluated. In CM, implants with 11.5º of internal inclination were investigated. The first test performed was the bending test following the methodology described in previous works.[16,17] In this first test, the null hypothesis was rejected, and statistical differences were found between the evaluated groups. After the bending test, an evaluation of the deformation pattern was performed in order to investigate the existence of a failure pattern between the evaluated groups. In this test, it was also possible to observe different failure patterns between the two groups evaluated.

Different studies investigated the fracture resistance of dental implants with different types of tests. [18-20] The bending test is an important method of assessing the mechanical behavior of dental implants.[21] The test was performed by applying load to the implant positioned 90 degrees in a metallic holder. For the bending test, severe bone reabsorption was simulated by positioning the implant 4 mm above the metallic holder. The samples were loaded by stainless steel spherical point until failure or until 5 mm of displacement. All samples presented failure prior to reaching maximum

displacement. The minimum and maximum displacement found was 2.6 mm and 3.1 mm, respectively. Implant diameters in this study were 3.5 mm, and implant lengths were 13 mm. These dimensions were chosen specially for comparing different implant designs with comparable dimensions. Implants with 16º of internal inclination were more resistant than implants with 11.5º. Although this situation is clinically impossible, the intention was to place the samples in the greatest possible difficulty.

The systematic review by Schmitt CM points out in the discussion that the most intriguing results were found at in-vitro studies that applied load off the long axis of implants. Deformation analysis were important to determine if there is any difference in the deformation pattern of the investigated groups. Although the system investigated in the GM group is more resistant, this analyze showed that the cervical region of these implants is more susceptible to deformation when the yield limit is exceeded. In the CM group, the deformation pattern was different. In these implants, the deformation occurred in the middle third. The implants investigated in all groups of this study were 3.5mm. Cervical deformation is directly dependent on implant diameter which is also determinant for resistance. [14]

CONCLUSION

Within the limitations of this in-vitro study, all groups presented a standardization of resistance to fracture. However, the group with the largest internal taper angle (16º) presented a higher resistance when compared to the

group with the lowest internal taper angle (11.5º). The groups evaluated presented a different deformation pattern.

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FIGURE LEGENDS

Fig. 1: Metallic holder and the stainless-steel spherical point loading the sample, performing the bending test.
Fig. 2: Scatter Plot Column Means showed the higher and lower results.
Fig. 3: Deformation pattern GM group.
Fig. 4: Deformation pattern CM Group.

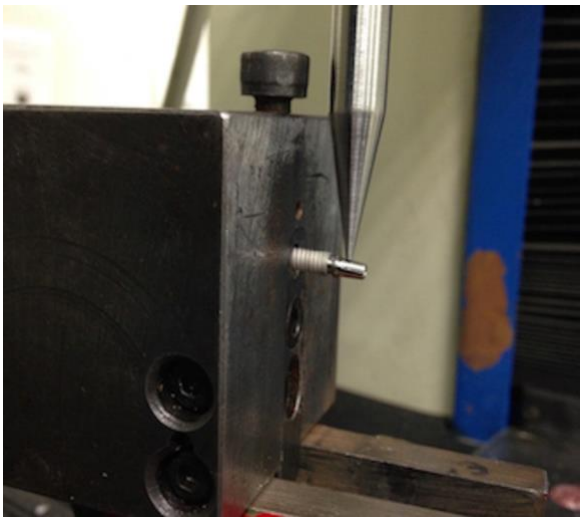
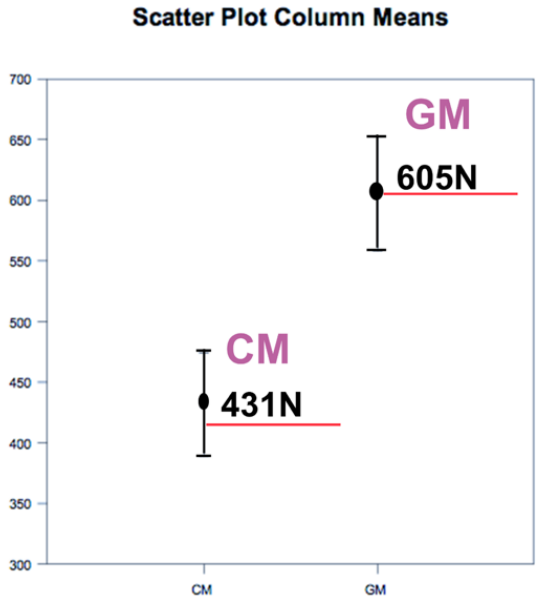


Fig. 1


Scatter Plot Column Means
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GM
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431N
CM
GM

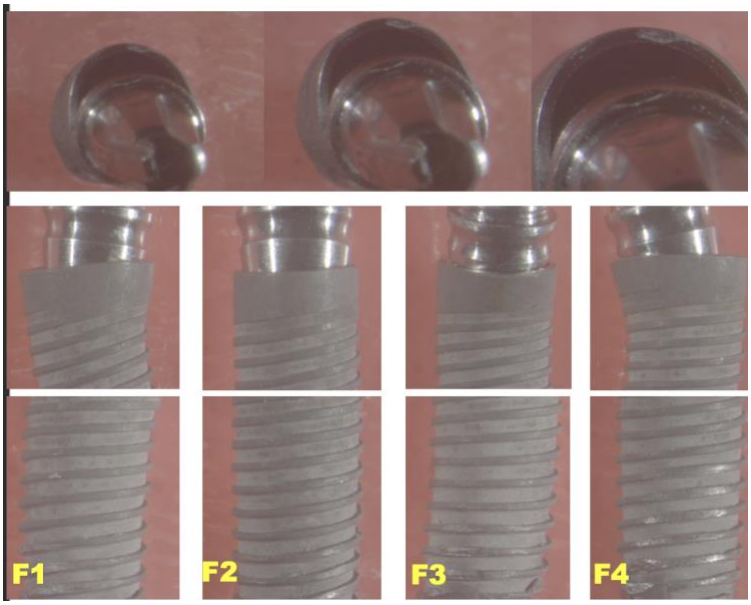
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Fig. 3

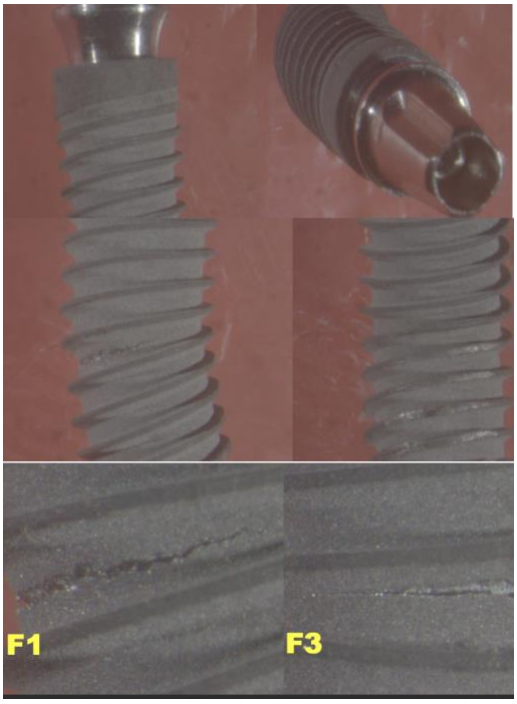

Fig. 4

TABLES

Table 1. Group Descriptions

Group	Descriptions
CM	Morse taper implant without prosthetic index (ø 3.5 × 13.0 mm), with 11.5-degree angulation of the internal conical portion and Universal Post (ø 3.3 × 4.0 × 1.5 mm), Neodent
GM	Morse taper implant without prosthetic index (ø 3.5 × 13.0 mm), with 16-degree angulation of the internal conical portion and Universal Post (ø 3.3 × 4.0 × 1.5 mm), Neodent

Table 2. Mean fracture results and standard deviation.

Groups	GM	CM
MeanValues	605 ± 47N A	431 ± 47N B

CAPÍTULO 2.3 –

Frederick Khalil Karam, Karla Zancopé, Flávio Domingues das Neves. Biological Performance of Morse Taper implants : Microinfiltration and Three-Dimensional X-Ray Microtomography. The International Journal of Oral & Maxillofacial Implants.

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Abstract

Purpose: The establishment of peri-implant bone height is unpredictable, and its maintenance may be related to mechanical and microbiological aspects related to the abutment/implant connection (A/I). It is proven that the type of A/I connection is directly related to the bacteriological infiltrate and the presence of inflammatory cells that lead to bone loss around gap in the connection region. Thus, the aim of this study was to evaluate, by microtomography and microleakage, implant-abutment microgaps at the implant abutment interface with Morse taper implants with 16° and 11,5° taper angle. Material and Methods: Sixteen Morse taper implants (Neodent) were specific prepared with an internal channel for the present study. The samples were divided in 2 groups (n=8): GM (16° implant/abutment); CM (11.5° implant/abutment) and the microleakage test were performed following. For the microtomography test, a Skyscan microtomograph was used to analyze the images of implants with 16° and 11,5° taper angle and their respective abutments.

Results: During the entire microinfiltration test there was any colored solution that could demonstrate the presence of a microscopic space and consequently, microleakage. The microtomographic test was performed and when analyzing the images, we observed that there was no hypodense image in any of the groups that characterized the presence of a microgap between abutment/implant.

Conclusion: Regardless the internal angulation of the dental implant, there is no presence of a migrogap between the abutment/implant junction.

Keywords: Morse taper, micro-st, microleakage.

Introduction

Dental implants originally developed by Brånemark had the external hexagonal design on the platform, used both in surgical installation of the implants and in connection with the abutment. This type of connection, according to a longitudinal clinical follow-up study that evaluated your success rates, found a bone loss around them considered normal, approximately 1.0 mm in the first year in function and less than 0.2 mm after first year.[1,2] However, while the establishment of peri-implant bone height is unpredictable,[3] its maintenance is subjective and is related to mechanical[4] and microbiological aspects[5-7] related to abutment/implant connection (A/I). [8]

The abutment/implant mismatch has been indicated as one of the causal factors of prosthetic failures[9] and possibly the bone loss around the implant platform.[5,6] It is proven that the type of A/I connection is directly related to the bacteriological infiltrate and the presence of inflammatory cells that lead to bone loss around gap in the connection region. [5,6]

Sealing the abutment / implant region is important to ensure benefits from the Morse taper connection. Other factors may influence the biological and biomechanical benefits, observed in Morse taper implants.[10] Trademarks may produce implants with some differences, such as the internal taper angle and the raw material used in their manufacture. Different taper angles of Morse taper junctions may raise further questions. Implants are designed to replace missing teeth and support chewing load. Thus, it is important to investigate benefits and damages of all joints. One way is to compare the degree of microleakage of different internal angles of Morse taper implants and correlate

with a possible change in the interface during this process. Although the literature presents several studies on microleakage, these authors did not find data that correlate microleakage with the internal taper angle of Morse taper implants. Beyond microleakage, perform a microscopic evaluation of the implant abutment region in different types of implants, using a computed microtomography methodology[11] is necessary. With this evaluation it is possible to determine if there is any microgap in the abutment / implant region by non-destructive testing of samples.

Thus, the aim of this study was to evaluate, by microtomography and microleakage, implant-abutment microgaps at the implant abutment interface with Morse taper implants with 16° and 11,5° taper angle.

Materials and Methods

Samples

Sixteen Morse taper implants (Neodent) were specific prepared for the present study. The samples were manufactured with a channel from the apical to the base of the screw chamber within the implant (Figure 1). The samples were divided in 2 groups (n=8): GM (16° implant/abutment); CM (11.5° implant/abutment) described on Table 1.

Microleakage Test

For the microleakage test, the implants were installed in plastic tubes through the drill sequence: (1) Lance, (2) Helical of 2 mm diameter, (3) Pilot and (4) Helical of 3.15 mm. The abutments were assembled to the implants with 15 Ncm insertion torque, as recommended by manufacturer. The screw hole was sealed with Teflon and two layers of resins. The deepest region was sealed using Teflon, the intermediate region with Opallis flow resin (FGM, Joinville) and the with microhybrid resin (Fillmagic, Vigodent) (Fig 2). The interface between the implant and the plastic tube was also sealed using flow resin (FGM, Joinville), followed by microhybrid resin (Fillmagic, Vigodent) that were wrapped by Teflon in order to avoid any leakage for these ways (Fig 3).

Solution Preparation

To perform the test, a solution was prepared with a concentration of 0.5% dissolving 0.5 mg of Toluidine Blue ($C_{15}H_{16}ClN_3S$) in 10 ml of distilled water. A high precision scale (Analytical Scale Mars Model Ay 220) (Fig 4) was used to measure the correct amount of toluidine blue powder and a mixer (Biomixer 78 HW - 1) (Fig 5) to obtain the solution. The test equipment (Fig. 6A) consists of a compressed air control marker (Fig. 6B); a compressed air release valve (Fig. 6C); a compressed air passage hose (Fig. 6D); hose plug (Fig. 6E) and a clear cylindrical container (Fig. 6F).

The hose plug must be removed and fitted into the plastic tube + implant + abutment assembly and the interface must be sealed with Teflon (Fig. 7).

Apply 4uL of the solution into this assembly using automated pipettes and reconnect the assembly to the hose. The solution was injected from the inside out and the value of 4 uL was obtained by means of a pilot test performed previously. These hoses must be fitted to the equipment and the plastic tube + implant + abutment set inserted into the transparent cylindrical container containing distilled water (Fig 8). With the set immersed in the cylinders, the test was started by injecting a pressure of 2 bahr for 1 hour.

Microtomography Test

For the microtomography test, a Skyscan microtomograph (Fig 10) was used to analyze the images of implants with 16° and 11,5° taper angle and their respective abutments. This test seeks to accurately evaluate, without destroying or invading the material, the possible presence of a microgap between the abutment/implant interface, measuring the contact sand of two different types of implants. To avoid any kind of image distortion, the implants were coupled in a cylinder-shaped mold. We used some parameters to perform the test (Table 2).

The images obtained in the test were processed by a dedicated reconstruction software (CTAM) efficiently reproducing the 3D image obtained from the implant.

Results

The microinfiltration test was analyzed at three moments during the deposit of the dye. During the entire test there was any colored solution that could demonstrate the presence of a microscopic space and consequently, microleakage (figure 11).

The microtomographic test was performed and when analyzing the images we observed that there was no hypodense image in any of the groups (figure 12 and 13) that characterized the presence of a microgap between abutment/implant.

Discussion

The present study tested the hypothesis that Morse taper implants with different internal taper angles presents the same degree of adaptation of abutments and implants when compared to each other. The groups were tested by two different methodologies: Computerized Microtomography and Microleakage. Both have already been performed in the literature[12] but not comparing different Morse taper implants. The hypothesis of this study was accepted, since there was no difference between the groups evaluated.

Computed microtomography is a non-destructive sample evaluation method used in the literature in different situations.[13-16] This method is validated for the evaluation of metallic and non-metallic structures.[11] The authors of this study observed some difficulties in using this methodology for these samples. This is due to the fact that the abutment and implant are metallic structures, and both are hyperdensively presented in microtomographic images. This may

mean a false-negative because it may not be possible to visualize any space by limitation of the microtomography methodology. This directly justifies the complementation of an auxiliary methodology in order to prove the results of this study.

Microleakage is a methodology applied in dental implants since 1999.[17] Most of the studies performed in literature use bacteria tests to assess the biological sealing of abutments and implants.[18-20] In previous studies by these authors, the need for dynamic tests was noted, since the biological sealing of dental implants does not occur statically in the oral cavity. In this study, the authors proposed an alternative methodology.[18] An equipment was developed (fig 4) in which compressed air is applied to the apex of perforated implants that are attached to specific cylinders. This methodology, although innovative in the literature, presents a potential. Instead of using bacteria, Toluidine Blue is used. This dye presents smaller molecules than the LPS present in the cell membrane of gram-negative bacteria. Thus, it was possible to evaluate, qualitatively, if there would be any leakage in the abutment/implant region. However, the methodology has limitations. The first is a qualitative methodology. The second, despite being a test in which a pressure is applied at the apex of the implant, it is still static. The implants do not go through any type of dynamic fatigue.

The mismatch between A/I has been indicated as one of the causal factors of prosthetic failure[9] and possibly by the reduction of bone around the implant platform.[5,6] It is proven that the type of junction between A/I is directly related to the bacteriological infiltrate and the presence of inflammatory cells that lead to bone loss around the existing microgap in the junction region. The

groups evaluated in this study demonstrated that, regardless of the internal taper, the biological sealing is maintained.

Other factors determine clinical success, such as implant fracture resistance and the switching platform effect described by Lazarra 2006.[3] In this study, it was observed that the inclination of the internal taper of Morse Implants will determine the thickness of the implant walls. Thus, implants with 3.5 mm in diameter, the greater the inclination of the internal taper, the smaller the implant wall and consequently the smaller the distance from the prosthesis/abutment/implant junction. Therefore, the authors suggest that in further studies, in addition to biological sealing and fracture resistance, the effect of platform switching in implants with different internal taper angles should be investigated.

Conclusion

After analyzing both tests, we certified that there was no presence of a microscopic space in both types of implants. Thus, we concluded that, regardless of the internal angulation of the dental implant, there is no presence of a migrogap between the abutment/implant junction. The results of these tests will be applied and evaluated in clinical practice.

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Figures Legends

Images

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

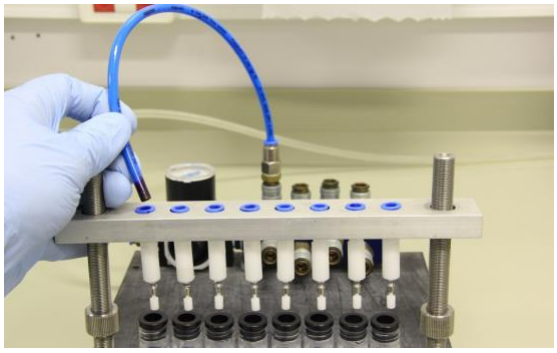

Fig. 6

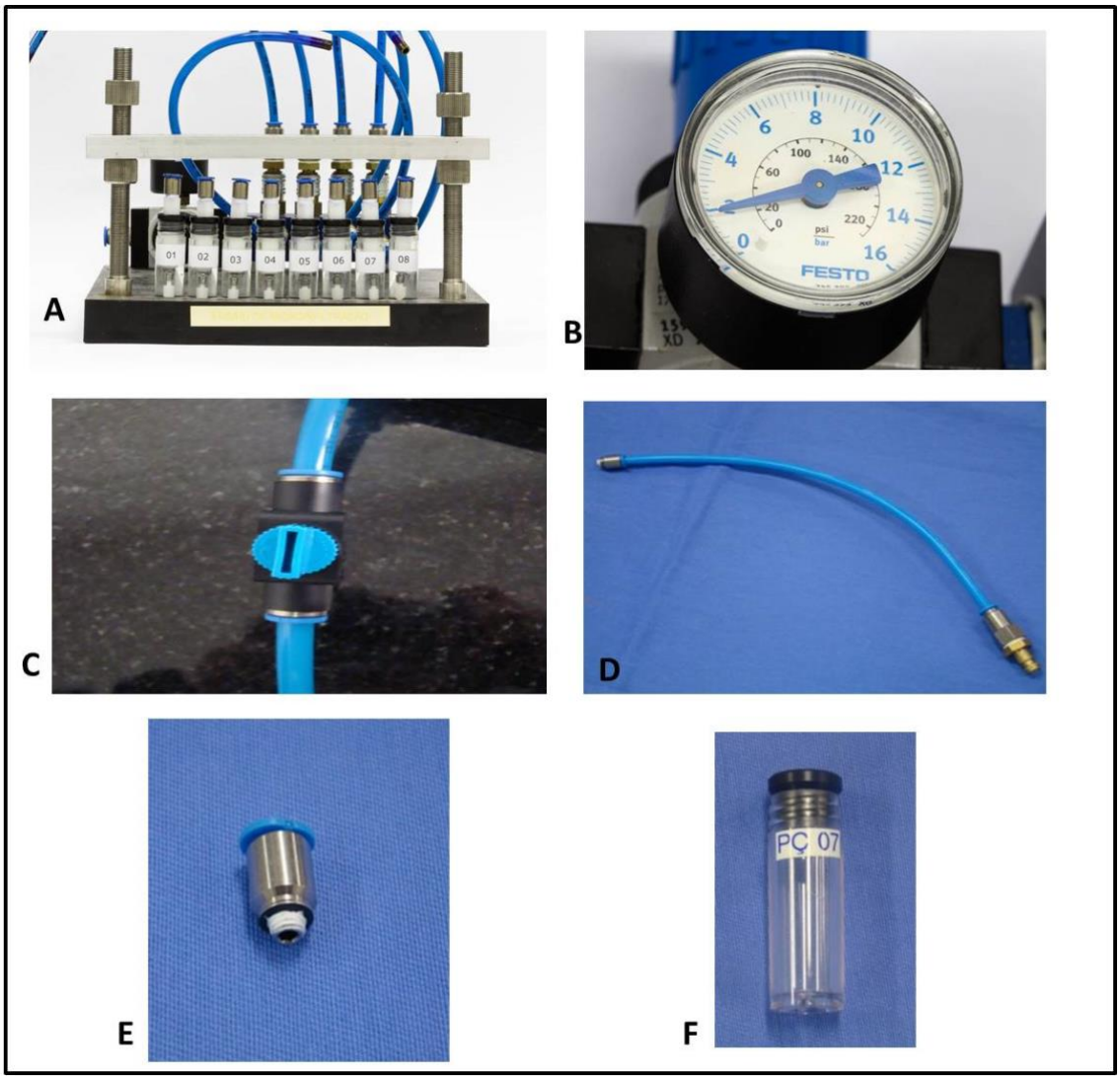

Fig. 6 A-F

Fig. 8

Fig. 9

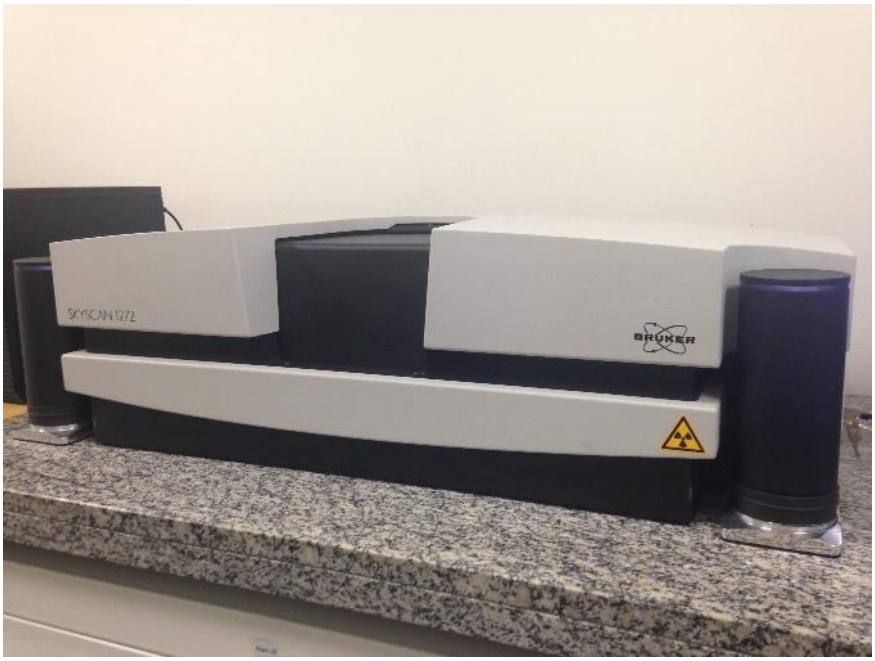

Fig. 10

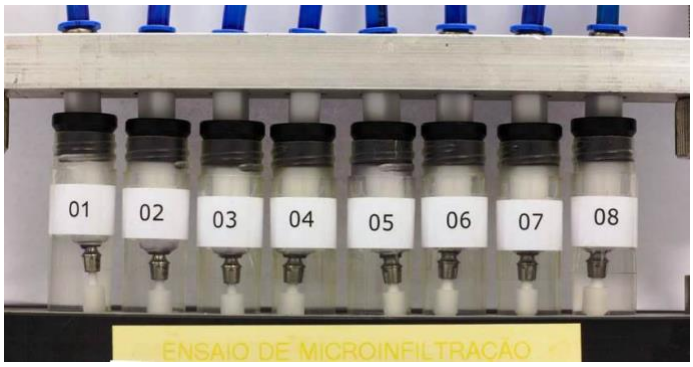

Fig. 11

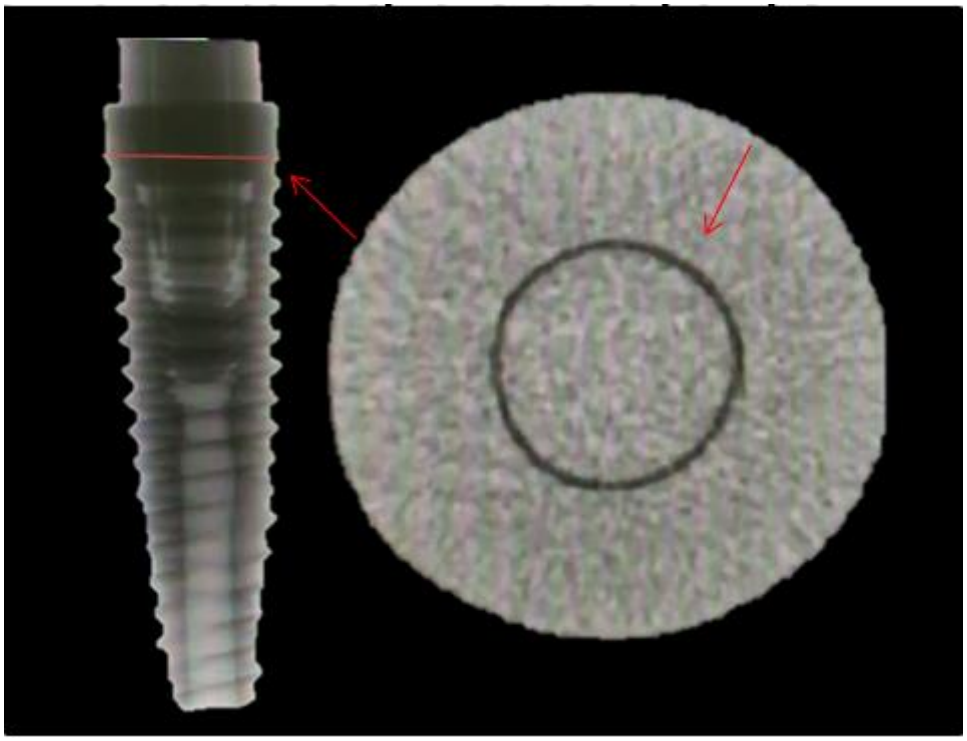

Fig. 12

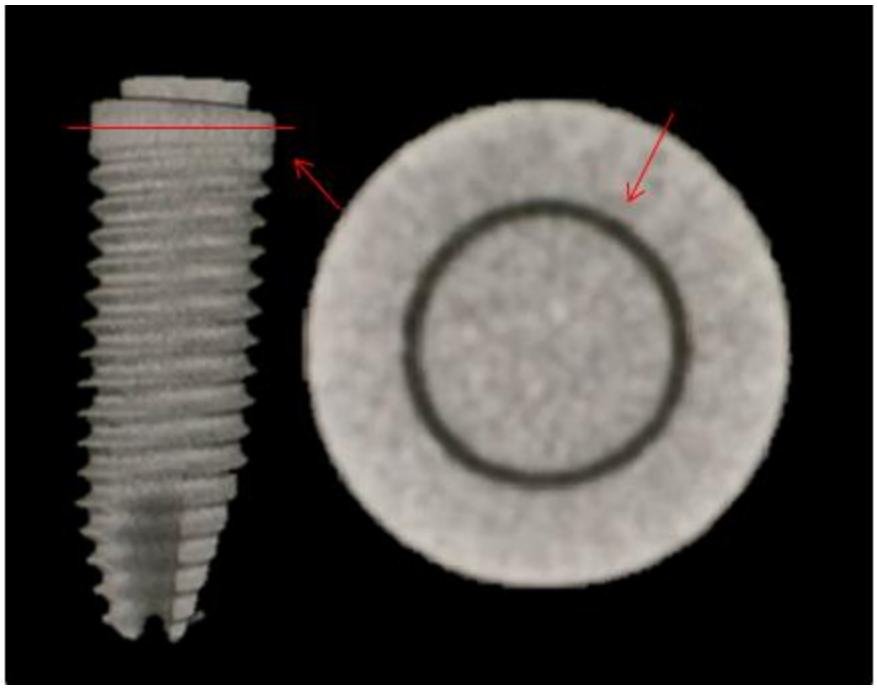

Fig. 13

Tab

Tab 1. Group Descriptions

Group	Descriptions
CM	Morse taper implant (ø 3.75 × 11.0 mm), with 11.5-degree angulation of the internal conical portion and Universal Post (ø 4.5 × 4.0 × 1.5 mm), Neodent
GM	Morse taper implant (ø 3.75 × 13.0 mm), with 16-degree angulation of the internal conical portion and Universal Post (ø 4.5 × 4.0 × 1.5 mm), Neodent

Tab 2. Parameters adopted for all sample

rotation step	0,45°
Total rotation angle	180°
power source	100KV/98 microA
filter thickness	1mm (Al)

3. Conclusão

3. CONCLUSÃO

De acordo com os resultados obtidos nos estudos laboratoriais, podemos concluir:

1- Independente da macrogeometria externa, o sistema pilar e implante com conicidade interna em 16° apresenta uma distribuição de carga mais homogênea quando comparado ao sistema pilar e implante com conicidade interna em 11,5°;

2- O sistema pilar e implante com conicidade interna em 16° apresentam uma resistência à fratura maior, quando comparado ao sistema pilar e implante com conicidade interna em 11,5°;

3- O fator conicidade interna, para os dois grupos avaliados, não apresentou microfenda quando avaliados por microtomografia computadorizada e teste de microinfiltração.

* De acordo com a Norma da FOUFU, baseado nas Normas de Vancouver. Abreviaturas dos periódicos com conformidade com Medline (Pubmed).

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