



**UNESP – Universidade Estadual Paulista
“Júlio de Mesquita Filho”
Faculdade de Odontologia de Araraquara**



Raphael Ferreira de Souza Bezerra Araújo

**Avaliação bidimensional e tridimensional da precisão de técnicas de moldagem
sobre implantes**

Araraquara

2019



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**Avaliação bidimensional e tridimensional da precisão de técnicas de moldagem
sobre implantes**

**Tese apresentada ao programa de Pós-graduação em
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Orientador: Prof. Dr. Francisco de Assis Mollo Junior

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Avaliação bidimensional e tridimensional da precisão de técnicas de moldagem sobre implantes

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Dedico este trabalho

à minha amada família

simplesmente por tudo que são e fazem por mim

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“Procure ser um homem de valor em vez, de ser um homem de sucesso.”

(Albert Einstein)

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RESUMO

Devido à importância da obtenção de passividade no sucesso de reabilitações protéticas sobre implantes, e ao fato da não observância de consenso sobre qual a melhor técnica de moldagem, o presente estudo tem por objetivo avaliar “in vitro” a exatidão de modelos totais, simulando uma reabilitação sobre implantes “All-on-4 Concept” na maxila, obtidos a partir de diferentes tipos moldeiras e técnicas de união dos transferentes de moldagem por meio da avaliação do desajuste vertical e da análise 3D da sobreposição de imagens digitais obtidas por escaneamento. Dose diferentes moldagens sobre implantes foram avaliadas, divididas nos seguintes grupos: Guia multifuncional com palato / transferentes unidos com metal e resina acrílica (PM); Guia multifuncional com palato / transferentes unidos com resina acrílica (PR); Guia multifuncional com palato / transferentes sem união (PC); Guia multifuncional sem palato / transferentes unidos com metal e resina acrílica (OM); Guia multifuncional sem palato / transferentes unidos com resina acrílica (OR); Guia multifuncional sem palato / transferentes sem união (OC); Moldeira plástica / transferentes unidos com metal e resina acrílica (MPM); Moldeira plástica / transferentes unidos resina acrílica (MPR); Moldeira metálica / transferentes unidos com metal e resina acrílica (MMM); Moldeira metálica / transferentes unidos com resina acrílica (MMR); Guia multifuncional / transferentes unidos com metal e resina acrílica (GMM) e Guia multifuncional / transferentes unidos com resina acrílica (GMR). Todas as moldagens (n=8) foram realizadas com silicone de adição na consistência densa e regular. Dois métodos de avaliação foram utilizados: registro dos desajustes verticais (adaptação cervical) e análise 3D da sobreposição de imagens digitais obtidas por escaneamento. Após verificação da distribuição e da homocedasticidade dos dados, métodos estatísticos ($\alpha=0,05$) foram empregados para avaliar a influência das variáveis independentes. Não houve diferença na precisão entre os grupos (GMM, GMR, MPM, MPR, MMM e MMR) tanto na avaliação da desadaptação marginal global e na análise 3D dos três eixos juntos (X, Y e Z). Assim como não houve diferença entre as técnicas de moldagem que utilizaram transferentes unidos (OM, OR, PM e PR) quando comparado com as técnicas de moldagem sem união dos transferentes (OC e PC) utilizando os valores de desadaptação marginal global e análise 3D dos três eixos juntos (X, Y e Z). Considerando as limitações desse estudo pode-se sugerir que a utilização da de diferentes moldeiras e técnicas de união dos transferentes não influenciou a precisão global dos modelos de gesso.

Palavras-chave: Prótese dentária. Implantes dentários. Adaptação marginal.

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ABSTRACT

Due to the importance of obtaining passivity in the success of prosthetic rehabilitation on implants, and because of non-observance of consensus on the techniques of impression, this study aims to analyze “in vitro” accuracy of total casts, simulating a rehabilitation of “All-on-4 Concept” in maxilla, obtained from different types of trays and techniques of union of transfers through the evaluation of vertical misalignment and of the 3D analysis of the overlap of digital images obtained by scanning. Twelve different impressions implants were evaluated, separated in this groups: Palate coverage multifunctional guide / metal and acrylic resin splint transfers (PM); Palate coverage multifunctional guide / acrylic resin splinted transfers (PR); Palate coverage multifunctional / without splint transfers (PC); Open palate multifunctional guide / metal and acrylic resin splint transfers (OM); Open palate multifunctional guide / metal and acrylic resin splint transfers (OR); Open palate multifunctional guide / without splint transfers (OC); Plastic tray / resin splinted transfers (MPR); Plastic tray / metal and resin splinted transfers (MPM); Metal tray / resin splinted transfers (MMR); Metal tray / metal and resin splinted transfers (MMM); Multifunctional guide / resin splinted transfers (GMR) and Multifunctional guide / metal and resin splinted transfers - GMM). All the impression (n=8) were made with polyvinyl siloxane impression material in putty and regular consistency. After verification of distribution and homoscedasticity data, statistical methods ($\alpha = 0.05$) were used to verify the influence of the independent variables. There was no difference was found between the groups (GMM, GMR, MPM, MPR, MMM e MMR) for evaluation of vertical misfit and in 3D analysis of the three axes together (X, Y and Z). As there was no difference between the impression techniques that uses splinted transfers (OM, OR, PM and PR) when compared to the impression techniques that used transfers without union for evaluation of vertical misfit and in 3D analysis of the three axes together (X, Y and Z). With the limitations of this study it can be suggested that the use of different trays and different techniques of transfers union did not influence the overall precision of the casts.

Keywords: Dental implant. Dental prosthesis. Dental materials. Impression techniques.

LISTA DE ABREVIATURAS

%	Porcentagem
<	Menor
>	Maior
°C	Graus Celsius
µm	Micrômetros
mm	Milímetros
min	Minutos
Co	Cobalto
Cr	Cromo
N	Newton
cm ²	Centímetros quadrados

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1 INTRODUÇÃO

A reabilitação oral total suportada por quatro implantes¹ (“All-on-4 concept”) com carga imediata para próteses fixas em acrílico na maxila é uma opção de tratamento eficiente nos casos de pacientes desdentados totais. Alguns estudos evidenciaram que não há diferenças significativas na distribuição de forças quando são utilizados quatro ou cinco implantes, e que a inclinação dos implantes posteriores melhora a distribuição das forças independentemente do número de implantes utilizados¹⁻³. Implantes inclinados são utilizados nesse tipo de prótese para diminuir a extensão horizontal de cantilevers e/ou evitando cirurgias de enxertia do seio maxilar, trazendo como vantagens adicionais uma melhor distribuição de implantes em casos desfavoráveis⁴.

Alguns trabalhos na literatura comprovaram a eficiência da biomecânica da reabilitação total suportada por quatro implantes. Maló et al.¹ (2003) propuseram um protocolo para a reabilitação simples da mandíbula edêntula em até 2 horas, o chamado conceito “All-on-4”. Foram instalados 176 implantes em 44 pacientes com carga imediata utilizando próteses metaloplásticas. Além dos implantes que receberam carga, 24 dos 44 pacientes tiveram 62 implantes “reserva” instalados, não incorporados nas próteses imediatas mas sim nas próteses definitivas. Dos implantes instalados, 45 foram colocados em alvéolos de extração frescos. Cinco implantes foram perdidos em cinco pacientes antes de 6 meses, com uma taxa de sobrevivência de 96,7% de sucesso. Não houve insucesso em próteses e a perda óssea marginal foi pequena. Essas informações consolidam os conceitos biomecânicos utilizados no sistema All-on-4^{2, 5}.

Soto-Penalozza et al.⁶ (2017) realizaram uma revisão sistemática sobre o “All-on-4 Concept” em relação às suas indicações, procedimentos cirúrgicos, protocolos protéticos e complicações técnicas e biológicas após pelo menos três anos de funcionamento. As três principais bases de dados eletrônicas foram analisadas: MEDLINE (via PubMed), EMBASE e Cochrane Library da Cochrane Collaboration (CENTRAL). Um total de 728 artigos foram encontrados a partir do processo inicial de triagem. Destes artigos, 24 preencheram os critérios de inclusão. Os autores concluíram que o tratamento com “All-on-4 Concept” oferece uma maneira previsível de tratar a pacientes com maxila atrófica sem a necessidade de cirurgias reconstrutivas, o que aumenta a morbidade e as fases de tratamento. Os resultados obtidos indicam uma taxa de sobrevivência de mais de 24

meses de 99,8%. No entanto, as evidências atuais são limitadas devido à escassez de informações relacionadas à qualidade metodológica e falta de acompanhamento adequado.

Em implantodontia, todos os passos, clínicos ou laboratoriais, têm influência direta no resultado final do trabalho reabilitador. Minimizar os erros acumulados nessas etapas pode aumentar a longevidade do tratamento⁷⁻⁹. Buscar um assentamento passivo de uma prótese implantossuportada é fundamental para o sucesso de uma reabilitação oral¹⁰. Diferentemente das próteses em dentes naturais, as sobre implantes, devido à ausência de ligamento periodontal, irão transmitir as forças diretamente aos tecidos perimplantares, tanto a tensão intrínseca da prótese, quanto a fisiológica, fazendo com que o sucesso da osseointegração dependa da maneira como os estresses mecânicos são transferidos dos implantes ao osso¹¹⁻¹³.

Mesmo após a osseointegração dos implantes, falhas de natureza tanto mecânica, quanto biológica, podem acontecer na ausência de passividade. Mecanicamente, pode haver desde o afrouxamento dos parafusos, até a fratura de componentes. Biologicamente, as falhas resultam na perda óssea ao redor dos implantes^{7,8,14}. A precisão de adaptação entre componentes protéticos em implantodontia pode ser influenciada por muitos fatores, destacando-se as etapas clínicas e laboratoriais, que estão envolvidas durante a execução do tratamento.

A realização da moldagem e produção do modelo de trabalho estão sujeitos às variáveis que podem alterar ou comprometer a biomecânica decorrentes de uma deficiente adaptação, entre implantes e componentes protéticos. Estudos recentes vem sendo desenvolvidos no intuito de produzir modelos de trabalho mais precisos e confiáveis na reabilitação com próteses implantossuportadas¹³⁻¹⁷.

Por mais avançadas que sejam as tecnologias empregadas na elaboração de técnicas e na confecção de materiais, pequenos erros, que vão desde a moldagem inicial até a instalação da prótese, estão frequentemente presentes no tratamento. Por isso, clinicamente, é impossível que uma adaptação completamente passiva seja alcançada na construção de uma prótese sobre múltiplos implantes, devido ao grande número de fatores relacionados¹⁸.

Buscando conseguir o melhor assentamento passivo, é fundamental realizar de forma precisa a transferência da posição tridimensional do implante da boca para o modelo de gesso. Entretanto, a precisão da moldagem de transferência é influenciada por diversos fatores, como: tipo união dos transferentes de moldagem, angulação dos implantes, número de implantes, distorção do material de moldagem, alteração dimensional do gesso e pelo desenho e rigidez da moldeira¹⁹.

Na prótese total fixada por 4 (“All-on-4 Concept”) ou mais implantes sofre mais influência com relação à estabilização de componentes de moldagem e consequente adaptação passiva. Porque nesse tipo de reabilitação há um maior número de implantes envolvidos, abrangendo toda arcada do paciente; a barra metálica, por consequência, também é extensa, sofrendo assim maiores influências no processo de confecção; a disposição dos implantes é em curva e, muitas vezes, com inclinações diferentes o que pode interferir negativamente na obtenção de modelos precisos^{15, 20}. Assim, todos esses fatores são contribuintes para uma maior possibilidade de falhas de adaptação nesse tipo de prótese, o que leva à necessidade de um cuidado maior na sua realização.

Assunção et al.²¹ (2004) avaliaram a precisão de três técnicas de moldagem em implantes angulados associados a diferentes materiais. Uma matriz metálica com quatro implantes com 90°, 80°, 75° e 65° graus em relação ao horizonte. Foram empregadas três técnicas de moldagem: T1 – Moldeira fechada com transferentes cônicos; T2 – Moldeira aberta com transferentes quadrados sem união; e T3 – Moldeira aberta com transferentes quadrados unidos com resina autopolimerizável; quatro diferentes materiais de moldagens: Polissulfeto, Poliéter, Silicone de Adição e Silicone de Condensação. Foi utilizado um projetor de perfil, com precisão de 0,017°, para análise das angulações dos implantes. Observou-se que o poliéter e o silicone de adição apresentaram melhor desempenho, e a técnica mais precisa foi a da moldeira aberta com os transferentes ferulizados com resina acrílica. Em relação a inclinação dos implantes, concluíram que quanto mais perpendicular for a angulação do análogo do implante em relação à superfície horizontal, mais preciso será o modelo.

Ozan e Hamis¹² (2019) avaliaram digitalmente 4 diferentes técnicas de moldagens sobre implantes utilizadas em reabilitações com prótese protocolo (“All-on-4”) variando a angulação (0, 10, 20 e 30 graus) dos implantes distais. As técnicas de moldagens

utilizadas foram: moldagem fechada utilizando transferente com “cap” plástico, moldagem fechada com transferente sem “cap” plástico, moldagem aberta com transferentes unidos entre si e moldagem aberta com transferentes reunidos após secção da primeira união. O material de moldagem utilizado foi o silicone de adição (Hydrorise Maxi Monophase; Zhermack). Como conclusão foi observado que os menores deslocamentos lineares e angulares foram obtidos a partir das moldagens abertas em comparação com as moldagens fechadas e o aumento da angulação dos implantes distais aumentou os desvios angulares e lineares.

Ozkomur e Manfroi²² (2018) ressaltaram a importância do planejamento reverso dentro da implantodontia. Segundo os autores, o correto diagnóstico através do enceramento e confecção de guias aumenta a previsibilidade do tratamento reabilitador. Sendo assim, a utilização do guia multifuncional, que fora produzido a partir da duplicação de uma prótese total, planejando a posição dos dentes na boca, para instalação dos implantes, novamente poderia ser utilizado, mas agora para favorecer a moldagem dos transferentes e, ao mesmo tempo, manter a dimensão vertical de oclusão do paciente.

Moldeiras metálicas, moldeiras plásticas e guia multifuncional (moldeira individual) são os tipos de moldeiras mais utilizados para moldar próteses totais fixas sobre implantes. Vários estudos recomendam a utilização de moldeiras rígidas, independente do material de moldagem utilizado. Por outro lado, moldeiras individuais (como o guia multifuncional) pode produzir modelos de gesso mais precisos já que a quantidade de material de moldagem utilizado é menor. Entretanto, não existem muitos estudos que comparem a influências das moldeiras na precisão da moldagem para confecção de prótese total fixada sobre implantes de prótese¹⁷.

Dentre os guias multifuncionais, dois desenhos são mais utilizados para realizar a moldagem em uma reabilitação oral em prótese sobre implantes do tipo protocolo, sendo um com cobertura de palato e outro com palato aberto. O guia multifuncional com cobertura de palato é mais rígido e estável, entretanto o guia com palato aberto possibilita um melhor acesso aos implantes pelo operador, facilitando assim o procedimento de moldagem²².

Del'Acqua et al.²³ (2012) avaliaram in vitro a precisão de duas técnicas de moldagem de transferência (Transferentes cônicos e Transferentes quadrados unidos). O material de moldagem utilizado foi o Vinil polisiloxano (Express – 3M ESPE) e dois tipos de moldeira (Plástica e Metálica). Foram utilizadas duas moldeiras plásticas (Morelli nº 7, Dental Morelli Ltda, Sorocaba, SP, Brazil) e duas moldeiras metálicas (Tecnodent nºI-4, Tecnodent Indústria e Comércio Ltda, São Paulo, SP, Brazil). Foi utilizado o adesivo (3M-ESPE) para retenção do material de moldagem nos grupos que utilizaram moldeira plástica. Quatro grupos experimentais (n=5) foram avaliados: TM – Transferentes cônicos/Moldeira metálica; SM – Transferentes quadrados unidos com metal e resina Duralay(Duralay, Reliance Dental Mfg. Co., Worth, IL)/Moldeira metálica; TP – Transferentes cônicos/Moldeira Plástica e SP – Transferentes quadrados unidos com metal e resina Duralay (Duralay, Reliance Dental Mfg. Co., Worth, IL)/Moldeira Plástica. A técnica do vazamento com tubos de Látex e gesso tipo IV (Vel-Mix, Kerr Corporation, Orange, CA, EUA), foi realizada duas horas após o ato de moldagem sob espatulação mecânica a vácuo (Turbomix, EDG Equipamentos, São Carlos, Brasil). A estrutura metálica foi parafusada com um torque de 10 N.cm em todos os corpos de prova no análogo A, enquanto as medições das fendas formadas foram feitas nos análogos C e D. Este processo foi repetido no análogo D, anotando-se as medidas dos análogos A e B. Foram realizadas 60 leituras utilizando um software que recebia as imagens de uma câmera de vídeo(JVC, 0.5-inch charge-coupled distributor, model TK-C1380 acoplada a um microscópio (Leica Microsystems) com ampliação de 100X. Os dados foram analisados estatisticamente (ANOVA, Onw-way/Kurskal-Wallis/método de Dunn, $p < 0,05$). Os valores médios das fendas encontradas foram: Modelo Mestre (controle) = 32 μm (SD 2); TM = 44 μm (SD 10), SM = 69 μm (SD 28), TP = 164 μm (SD 58); SP = 128 μm (SD 47). Nenhuma diferença significativa foi encontrada entre o controle, TM e os grupos SM e entre os grupos TP e SP. ($P > 0,05$). Dessa forma, nas condições deste estudo, as seguintes conclusões podem ser tiradas: Resultados estatisticamente semelhantes foram obtidos com as moldagens realizadas com transferentes cônicos e com transferentes quadrados unidos quando utilizado material de alta viscosidade (Putty - Express – 3M ESPE). A rigidez da moldeira de estoque metálica garante melhores resultados que a moldeira plástica.

Em relação ao método de união dos transferentes para a realização da moldagem sobre implantes Del'Acqua et al.²⁴ (2008) e Jo et al.²⁵ (2010) concluíram que a técnica com transferentes quadrados é melhor do que a com transferentes cônicos. Quanto ao método de união dos transferentes quadrados, Ivanhoe et al.²⁶ (1991) descreveram uma técnica com os transferentes quadrados unidos com resina composta fotopolimerizável. Vigolo et al.²⁷ (2003), Naconecy et al.²⁸ (2004), Del'Acqua et al.²⁴ (2008), Al Quran et al.¹⁴ (2012), preconizaram a união dos transferentes quadrados com resina acrílica para realização das moldagens de transferência em implantes de hexágono externo, obtendo-se dessa forma os melhores resultados.

Papaspyridakos et al.¹³ (2016) avaliaram o efeito do tipo de conexão (plataforma do implante ou intermediário protético) e técnicas de moldagem na precisão de adaptação de próteses totais fixas sobre implantes. As moldagens nesse estudo foram realizadas diretamente na plataforma do implante ou nos intermediários protéticos utilizando transferentes unidos entre si e também transferentes sem união, o material de moldagem utilizado foi sempre o poliéter (Impregum; 3M ESPE). Eles observaram que na técnica de moldagem diretamente na plataforma do implante a utilização de transferentes unidos entre si apresentaram melhores resultados do que a técnica de moldagem sem união dos transferentes. Porém, para a técnica de moldagem realizada sobre o intermediário protético a união ou não dos transferentes não influenciou na precisão de adaptação.

Baig²⁹ (2014), considerando o procedimento de moldagem de transferência de implantes fundamental para se obter uma prótese passiva, revisou a literatura científica sob diferentes aspectos. O autor avaliou trabalhos entre os anos de 1990 e 2012. Após aplicar os critérios de exclusão, cinquenta e nove trabalhos foram selecionados, sendo que três clínicos e todos os demais estudos laboratoriais. Segundo o autor, quinze estudos compararam silicone de adição e poliéter. Desses, onze não acharam diferenças entre os dois materiais. Trinta trabalhos avaliaram a eficiência da união dos transferentes, dos quais treze consideraram melhor unir e outros trezes não acharam diferenças entre unir ou não os transferentes. Dos vinte e cinco trabalhos que compararam transferentes de moldeira fechada e moldeira aberta, doze consideraram moldeira fechada superior e onze não acharam diferenças entre ambos. Doze estudos

avaliaram a influência da angulação de implantes e acharam diferenças estatisticamente significantes com angulações entre 20 e 25 graus e sem diferenças estatisticamente significantes com angulações entre 5 e 15 graus para a maioria dos trabalhos, exceto dois. O autor concluiu que: silicone de adição e poliéter são os materiais de eleição para moldagem de transferência de implantes; a evidência para unir, é fraca e os resultados de unir e não unir se equivalem; transferentes para moldeira aberta são mais eficientes; implantes com angulações entre 20 e 25 graus interferem na precisão da transferência.

Flügge et al.³⁰ (2018) realizaram uma revisão sistemática e meta-análise para avaliar e comparar a precisão das moldagens de implantes convencionais e digitais. Foram selecionados 79 estudos entre 2012 e 2017 sobre moldagens de implantes, sendo 77 estudos experimentais, um ensaio clínico controlado e um retrospectivo. A maioria dos estudos incluídos (75) foram realizados *in vitro* e quatro *in vivo*. Os resultados das moldagens de implantes convencionais e digitais exibiram alta heterogeneidade. Eles concluíram que os dados disponíveis para avaliar a precisão das moldagens (digital e convencional) de implantes têm um baixo nível de evidência e não incluem dados suficientes de estudos *in vivo* para aplicação de recomendações clínicas.

Dessa forma, devido a importância da obtenção de passividade no sucesso de reabilitações protéticas sobre implantes, da possibilidade de implantes angulados interferirem na obtenção de modelos precisos, da não observância de consenso na literatura sobre as técnicas de moldagens, da ausência de trabalhos que avaliem a moldagem em reabilitações baseados no “All-on-4 Concept” em maxila comparando diferentes tipos de moldeiras e técnicas de união dos transferentes, a proposta deste estudo foi avaliar “*in vitro*” a exatidão de modelos totais, simulando uma reabilitação sobre implantes “All-on-4 Concept” na maxila, obtidos a partir de diferentes tipos moldeiras, técnicas de união dos transferentes de moldagem por meio da avaliação do desajuste vertical e da análise 3D da sobreposição de imagens digitais obtidas por escaneamento.

2 PROPOSIÇÃO

2.1 Geral

Avaliar “in vitro” a exatidão de modelos totais, simulando uma reabilitação sobre implantes “All-on-4 Concept” na maxila, obtidos a partir de diferentes tipos moldeiras e técnicas de união dos transferentes de moldagem por meio da avaliação do desajuste vertical e da análise 3D da sobreposição de imagens digitais obtidas por escaneamento.

2.2 Específica

- Artigo 1: Comparar efeito da utilização de diferentes tipos de moldeiras (guia multifuncional, moldeira plástica e moldeira metálica) e diferentes técnicas de união dos transferentes (unidos com metal/resina e unidos apenas com resina acrílica) na moldagem em prótese sobre implantes (All-on-4 Concept) sobre a exatidão global dos modelos totais de gesso por meio da avaliação do desajuste vertical e da análise 3D;

- Artigo 2: Comparar efeito da utilização de dois desenhos de guia multifuncional (guia multifuncional com palato e guia multifuncional sem palato) e diferentes técnicas de união dos transferentes (unidos com metal/resina, unidos apenas com resina acrílica e sem união) na moldagem em prótese sobre implantes (All-on-4 Concept) sobre a exatidão global dos modelos totais de gesso por meio da avaliação do desajuste vertical e da análise 3D;

3 PUBLICAÇÕES

3.1 Artigo 1*

Accuracy of impression techniques with maxillary angled implants using trays and multifunctional guides

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* Este artigo segue as normas do periódico (Clinical Oral Investigation) o qual foi submetido e está em revisão.

Accuracy of impression techniques with maxillary angled implants using trays and multifunctional guides

ABSTRACT

Purpose: The purpose of the present study was to evaluate *in vitro* the accuracy of different splinted techniques of the transfers combined with different types of trays.

Materials and methods: A maxillary master cast with four implants were fabricated and a passive metallic bar was made on this master cast. Forty eight casts were obtained by using six different impression techniques (metal tray / resin splinted transfers - MMR, metal tray/metal and resin splinted transfers - MMM, plastic tray / resin splinted transfers - MPR, plastic tray / metal and resin splinted transfers - MPM, multifunctional guide / resin splinted transfers – GMR, multifunctional guide / metal and resin splinted transfers - GMM) (n=8) with polyvinyl siloxane impression material. A passive metallic bar was used to measure the misalignment between the framework and the analogs (A, B, C and D). The master cast and the experimental cast were scanned with a contact scanner to compare the accuracy in 3D impression techniques. Discrepancies between the analogs were measured in three X, Y, and Z axes. After verification of distribution and homoscedasticity data, statistical methods ($\alpha = 0.05$) were used to verify the influence of the independent variables.

Results: There was no statistically significant difference ($p > 0.05$) between the groups in the evaluation of vertical misalignments. In the 3D evaluation, for Z axis and combination of XZ axis, the MPM (Z=487 μm ; XZ=888 μm) was a statistically significant difference than the GMR (Z=772 μm ; XZ=1380 μm). For evaluation by analogue, for analogue C, the GMM (302 μm) presented statistically significant difference compared to GMR (492 μm).

Conclusion: The methods of evaluation of the precision of the technique of impression presented different results between them. The bonding of the transfers with metal/acrylic presented better results than the bond with only acrylic for the MPM and GMR groups, in the Z axis and in the combination between the XZ axis. For the multifunctional guide impressions, the bonding technique of the transfers with metal/acrylic presents better results in the 3D analysis.

Clinical relevance: With the “All-on-4 concept”, in the 2D and 3D global evaluation, impression techniques using polyvinyl siloxane produced similar accurate casts using different techniques of splinted transfer (metal or metal/acrylic) combined of different trays (metal, plastic and multifunctional guide).

Keywords: Dental implant. Dental prosthesis. Dental materials.

INTRODUCTION

Total oral rehabilitation supported by four implants (“All-on-4 concept”) with immediate loading for fixed acrylic prostheses in the maxilla is an efficient treatment option in cases of total edentulous patients¹. Some studies have shown that there are no significant differences in the distribution of forces when four or five implants are used, and that the inclination of the posterior implants improves the distribution of forces regardless of the number of implants used¹⁻³. Inclined implants are used in this type of prosthesis to reduce the horizontal extension of cantilevers and / or avoid grafting surgeries of the maxillary sinus, bringing as an additional advantage a better distribution of implants in unfavorable cases.^{4, 5}

However, passive settlement of fixed prostheses over four implants (“All-on-4 concept”) is a key success factor, and therefore precise impression is essential for the clinical success of rehabilitation treatment^{6, 7} because, differently from dentures in natural teeth, the over implants, due to the absence of periodontal ligament, will transmit directly to the perimplant tissues, both the intrinsic tension of the prosthesis and the physiological one, making the success of the osseointegration depend on the way the mechanical stresses are transferred from the implants to the bone.⁷⁻⁹

In order to achieve the best passive settling, it is essential to accurately perform the transfer of the three-dimensional position of the implant from the mouth to the cast. However, the accuracy of transfer impression is influenced by a number of factors, such as: bonding of mold transfers, implant angulation, number of implants, distortion of impression material, dimensional change of plaster, and the design and rigidity of the mold^{7, 10}. Among these factors that may influence the precision of the impression, the bonding of the transfers seems to be the most significant factor, especially in the cases

of 4 or more implants. During bonding, the distortion of the material used in the bonding and / or breaking of the bond between the bonding material and the transfer can adversely affect the accuracy of the impression. Further, the shrinkage of polymerization of the acrylic resin used in the bonding may decrease the precision of the impression.¹⁰

Metal trays, plastic trays and a multifunctional guide (individual tray) are the most commonly used tray types for impression fixed total dentures on implants. Several studies recommend the use of rigid trays, regardless of the impression material used^{11, 12}. On the other hand, individual trays (such as the multifunctional guide) can produce more accurate casts since the amount of impression material used is less. However, there are not many studies comparing mold influences on the accuracy of impression for total prosthesis fixation on prosthesis implants.¹¹⁻¹³

Thus, due to the importance of achieving passivity in the success of fixed total rehabilitations on implants, the possibility of angled implants interfere in the obtaining of precise casts, as well as the type of bonding of the transfers. Considering the fact that the tray type can affect the precision of the mold, the purpose of the present study was to evaluate *in vitro* the accuracy of total casts simulating a rehabilitation of "All-on-4 concept" implants in the maxilla obtained from of different types of molds (prototyped multifunctional guide, plastic and metal trays) and different bonding techniques of the transfers (transfers connected together with metallic rods and acrylic resin and bonded to each other only with acrylic resin) by means of the evaluation of vertical misalignment and 3D analysis of the overlap of digital images obtained by scanning.

MATERIAL AND METHODS

In a metallic cast of the maxilla, four external hexagon implants were installed with a regular platform (Conexão – Sistemas de Próteses). Two implants in the premaxilla region are parallel to each other and two implants with a 45 ° inclination in the posterior region to the canine fossa, simulating the "All-on-4 concept."

Intermediates were installed on the previous implants (Micro-Unit) with 3 mm straps (Conexão – Sistemas de Próteses), and intermediates were installed on the posterior implants (Micro-Unit) with a 3 mm strap and angled at 30 degrees, being the

master cast of the present study. A passive metallic bar was made on this master cast, simulating a metallic infrastructure for total prosthesis fixed by implants (Fig. 1).

- Impression

The impression were always made with the polyvinyl siloxane Express XT (3M ESPE), in dense and regular consistencies using three different types of trays: No. 06 plastic trays (Dental Morelli Ltda), S4 perforated metal trays (Moldeiras Tecnodent Indústria & Comércio) and a multifunctional guide.

In the impressions made with stock trays, perforations in the regions of the implants were made to pass through the screw of the square transfers allowing access to the same after the impression. On the other hand, the multifunctional guides used as trays were virtually designed from the contact cast scanning by the contact scanner (MDX-40, Roland, CTI, Campinas, SP, Brazil) calibrated at 0.2mm for each stroke of the contact tip on the scanned surface. The image generated in the * .STL file from the scanning was exported to the Bio-CAD program (Computer Assisted Desing; Rhino3D, Rhinoceros), serving as a mesh for the virtual drawing of the multi-purpose guide with a standard thickness of 2.5mm , simulating the conformation of a multifunctional guide used clinically. After the virtual drawing, this guide was made in an additive machine that works with Polyjet technology, Stratasys brand, model Objet350 Connex. The equipment works with photopolymerizable resins deposited by multiple injector heads.

For all impressions, putty polyvinyl siloxane was provided (a portion of each putty polyvinyl siloxane was weighed to use the same amount of material in all impressions) and handled following the manufacturer's recommendations. The regular polyvinyl siloxane was handled in a self-mixing tip coupled with the manufacturer's own dispenser (the amount of regular material used was also standardized for all impressions, using two clicks of the dispenser for each impression). The first 3.0 cm of this mixture was dispensed, guaranteeing the homogeneity of the material. Due to the incompatibility of the polyvinyl siloxane with the latex¹⁴, the putty polyvinyl siloxane were manually handled by a sole operator wearing vinyl gloves. In the multifunctional guide impression, the regular consistency polyvinyl siloxane was injected into the region of interest (around the transfers attached to the multifunctional guide) and then the dense material was inserted onto the regular material with a slight digital pressure to adjust the material to the

multifunctional guide. In the case of impression with stock trays, the light material was also injected around the transfers and the heavy material was placed in the tray to carry out the impression. After the impression, a 1kg mass was placed on the guide to standardize the pressure in all molds.

- Bonding Techniques of Transfers

Square cast impression transfers were used using two different bonding techniques:

- Square transfers bonded with acrylic resin (Pattern Resin, GC America Inc);
- Square transfers bonded with stainless steel rods and acrylic resin (Pattern Resin, GC America, Inc);

In the bonding technique where the square transfers were bonded with acrylic resin, acrylic resin (Pattern Resin, GC America Inc) was initially applied around the retentive portion of the square transfers. The previously fabricated acrylic resin cylinders were sectioned into appropriate lengths to close the space between the adjacent transfers.

Using the brush technique, the ends of the resin cylinders were attached to the transfers. A resin polymerization period of at least 17 minutes prior to its sectioning and re-bonding was expected^{15, 16}. Although Ivanhoe et al.¹⁴, 1991 left 1 mm of space between each transfer, only the space created by cutting the resin cylinder with a double-sided diamond disc was standardized. It is possible to minimize tensions produced by resin contraction (De La Cruz et al. ¹⁷, 2002). After the cut, the cylinders were re-bonded with acrylic resin, and another 17 min were expected for the impression^{15, 16}. In the case of multifunctional guide impression, the transfers were also attached to the guide with acrylic resin.

For the bonding method where square transfers were bonded with stainless steel rods and acrylic resin, these transfers were initially bonded together with 2.3 mm diameter stainless steel cylinders (simulating chip fragments) with cyanoacrylate (Super- Bonder - Locitite). Later, this bond was reinforced with acrylic resin (Pattern Resin, GC America Inc) by the brush technique, and waited 17 minutes for the impression^{15, 16}. In the case of multifunctional guide impression, the transfers were also attached to the guide with acrylic resin.

- Sample group

The experimental groups of the present study were divided according to Table 1 below:

- Production of casts

After 2 hours of the casting, the analogs were installed in the mold, 120g of gypsum stone type IV (Fuji Rock EP - America Inc - USA) was mechanically spatulated under vacuum for 30 seconds and poured into small portions until complete filling of the mold. Plastic boxes were used as auxiliary molds in the casting of the plaster allowing the standardization in the format and quantity of plaster employed for the casting. After 60 minutes, the transfer screws were unscrewed again and the mold / cast assembly was separated, providing the replica of the master cast (Fig. 2). For each group, 8 casts were produced. The obtained casts were stored at room temperature for at least 120 hours until measurements were taken.

- Record of vertical misalignments (cervical adaptation)

The metal bar was screwed into the leftmost analog (analog A) in each cast of gypsum obtained, as well as in the master cast (control group) with a titanium screw with a torque of 10 N.cm¹⁸ to maintain the structure in a constant position while measurements were made on the contralateral analogs (C and D). Subsequently, the screw was removed from analog A and screwed to the right posterior analog (analog D), while the process of reading the mismatches was done on analogs A and B (Fig 3).^{1, 19, 20}

The same positioning was standardized (posterior base of the cast supported on the base of the magnifying glass) to carry out the measurements, both in the master cast and in the experimental casts. It was guaranteed that all measurements were made with the same intensity of light with the same angle of incidence and with the same distance from the cast to the magnifying glass. A LEICA loupe (manufactured in Singapore) was used to enlarge (100X) and record the image of the gap formed between the metal structure and the analogs. Slit measurements were made using the LEICA QWin program (Leica Imaging Systems Ltd, Cambridge, England). For each analog, three readings were performed, one in the center and two more lateral (Fig. 4), totaling 12 readings per test piece.

- 3D evaluation of the overlap of digital images obtained by scanning

The gypsum casts, as well as the master cast, were scanned by the Contact Scanner (MDX-40, Roland, CTI, Campinas, SP, Brazil) calibrated at 0.2mm for each scanning of the contact tip on the scanned surface generating images in files. * STL files were exported to the Bio-CAD (Computer Assisted Desing, Rhino3D, Rhinoceros, USA) program for analysis and overlap of images with the objective of evaluating the degree of fidelity of experimental cast in relation to the master cast. This overlapping of the images was guided by the pyramid present in the casts. For this analysis, initially the points of each face of the pyramid were selected in the Bio-CAD program, and plans were projected from these points, forming an intersection point and edges between them. With the edges and intersection point defined, it was possible to overlay the gypsum cast files in relation to the master cast, acting as reference for this overlap. In this way, it was possible to evaluate the difference in the position of the 3D analogs (in the X, Y and Z axes) of the casts of the experimental groups and of the master cast, the intersection point between the planes of the pyramid being the absolute position 0 in the X (lateral), Y (anteroposterior) and Z (vertical). With this, it was possible to calculate the absolute position of the A, B, C and D analogs in relation to the position of the point of intersection of the pyramid by the Bio-CAD program (Fig. 5).

- Statistical analysis

From the data obtained and with the aid of the SigmaStat version 3.11 program (Systat Software, Inc.) the results were analyzed statistically to establish the conclusions. Normality test and equality of variance were made to decide the best statistical test to be used for each comparison to be made.

RESULTS

-Record of vertical misalignments (cervical adaptation)

There was no statistically significant difference ($p > 0.05$) between the groups after using the non-parametric Kruskal-Wallis test (Failure in normality), obtaining Table 2 below.

Regardless of the bonding technique between the transfers and the type of tray used, the values of global marginal misalignment between the metallic infrastructure and

the analogs, which were found, did not present discrepant numbers. It is important to note that GMM and GMR are not statistically significantly different from GMM and GMR, since the GMM group had a misalignment value of 181.18 μm and the GMR group with 99.22 μm .

- 3D evaluation of the overlap of digital images obtained by scanning

Results by axis

There was no statistically significant difference between the groups for the X axis, the Y axis, the combination of the XY axes, the combination of the YZ axes and the combination of the XYZ axes.

Z axis: There was a statistically significant difference between the groups ($p = 0.038$) – one way Anova and the Tukey`s test (Table 3).

XZ axis: There was a statistically significant difference between the groups ($p = 0.032$) - one-way ANOVA and Tukey`s test (Table 4).

Results by analogue

There was no statistically significant difference between the groups for analog A, for analog B and for analog D.

Analog C: There was a statistically significant difference between the groups ($p = 0.037$) - one-way ANOVA and the Tukey`s test (Table 5).

DISCUSSION

The oral rehabilitation of edentulous patients with total dentures fixed by implants presents favorable aspects in relation to occlusal loads due to their rigid bond and their polyhedral arrangement. However, for their success, the bond must be rigid and passive between multiple implants. This passivity confers the prosthesis a biomechanical balance that will lead to clinical success. Thus, one of the main objectives in the manufacture of a total fixed implant is to obtain a metallic or ceramic infrastructure that has a passive fit when placed on multiple implants.^{2, 20, 21}

When using this type of prosthesis, several variables can interfere in the passive adaptation of the infrastructure, such as the impression material used, the method for transfer bonding, the use of different types of media (plastic tray, metal tray and multifunctional guide) to perform the casting, the amount of gypsum used in the casting,

the inclination of the implants, among others^{9, 17, 22}. Thus, some of the variables of the present study were controlled with the purpose of standardizing them, such as: the use of standard amount of gypsum during mold casting; the use of prototyped multifunctional guides, plastic trays and metal trays for impression; the same settling pressure in all impression; the readings always made by the same operator and reading the slots always by the same angle.

In the present study, no statistically significant differences were found between the groups when using the vertical misalignment (cervical adaptation) method to evaluate the accuracy of the impression technique. This could be explained by the fact that only polyvinyl siloxane (regular and dense consistencies) was used as a impression material, which according to Morford²³ et al (1986) and Ozan and Hamis²⁴ (2019), is considered to be more stable and precise when compared to any other impression material with a rubber base, stabilizing the transfers inside the mold, generating casts with similar results. Lee²⁵ et al. (2008) found that the higher stiffness of the material provides greater resistance against a deformation of this by some factor during impression, for example screwing the analogs. And for Kurtulmus-Yilmaz²⁶ et al. (2014), the material has a good elastic recovery, giving the material good resistance and providing a better stabilization of the transfers.

However, in order to evaluate the accuracy of the implant impression, three-dimensional (3D) evaluation is recommended because distortions in the impression can occur on the X, Y and Z axes, so it is very important to analyze the distortion in these three dimensions^{10, 27, 28}. Two-dimensional evaluation (record of vertical maladjustment) is not as reliable, since the misalignment may be in a region where the reading is not being performed. In addition, measurements were made on the analogs after bar-screwing only in a contralateral analog, which amplifies the values of the slits, which makes the method of evaluation of the cervical adaptation less accurate and reliable than the 3D evaluation. Another relevant factor is the fact that the gypsum cast maladjustment measurements are made from a bar that already had a considerable misalignment in the master cast.

In our study when using the 3D evaluation method (on the X, Y and Z axes) of the casts obtained from touch scanning to evaluate the accuracy of the impression technique,

a statistical difference was observed in the Z axis between the GMR (772) and MPM (487) groups. Statistical differences were also observed between these groups when evaluated in the XZ axis combination, where the GMR group averaged 1380 μ m and the MPM group had a mean of 888 μ m. Many authors indicate the need for stabilization of the transfers to avoid rotational movements during screwing of the analog, ensuring that the transfers remain in position within the mold, generating more precise casts^{9, 24, 28, 29}, and the more stable and rigid this bond, the more accurate the casts, explaining the fact that the MPM group presented better results in relation to the GMR group, probably because the transfers were bonded with metal and resin (more rigid and stable bond). Vigolo²⁹ et al. (2003) verified the importance of avoiding the movement of the transfers inside the impression material in all the procedures related to the manufacture of the casts to obtain greater precision of the work. However, this is still a controversial point in the literature, since some studies could not find differences between impressions with bound and unbound transfers.

In spite of the advantages that the total fixed rehabilitation by four implants "All-on-4 concept" can offer in situations with anatomical and bony limitations, this type of concept hinders the impression procedure, making it difficult to obtain a faithful cast and consequently of the prosthesis with passive seating. The angulation of implants can cause less precise impression when compared to parallel implants, especially in cases of 4 or 6 implants²⁶. Kurtulmus-Yilmaz²⁶ et al. (2014), have shown that implant angulation has significant effects on impression accuracy. However, Shim³⁰ et al. (2015). observed that angulations of up to 15 degrees have no significant difference in the impression result, especially when these angles are in the mesio-distal direction. Vestibular-lingual angulations were shown to have a greater effect on the final precision. On the other hand, Ehsani³¹ et al. (2014) through three axis evaluation (X, Y and Z), observed that angled implants have no significant difference when compared to the parallel ones. In this study, when performed the analog evaluation, was observed a difference only between the MMM (366 μ m) and MMR (436 μ m) groups for the C analog (which is a parallel implant), with no difference between angled implants. This can be explained because most of the literature studies that state that implant angulations have significant effects on the accuracy of the impression did this evaluation in impression performed directly on the

implant platform, differently from our study where the impressions were performed with the conical component transfers (Micro-Unit). This component has a conicity of 20 degrees, and it is easier to achieve a better adaptation in clinical situations where the implants have different angulations between them.

In the study by Del'Acqua¹¹ et al. (2012), it was found that the rigidity of the metal tray mold ensured better results than the plastic tray in polyvinyl siloxane transfer impressions. Thus, these authors demonstrated that the rigidity of the mold used in the impression can influence the accuracy of the casts, being one of the reasons which explain the fact of the impression technique. However, in this study did not observe differences in the results (2D and 3D) when comparing different types of trays (metal, plastic and multifunctional guide), corroborating with the results of Al Quran¹⁵ et al. (2012) and in the systemic review of Flügge⁹ et al. (2018) that concluded that the bonding technique of the transfer seems to influence the final precision of the mold more than the stiffness of the mold.

When comparing the methods to evaluate the accuracy of the impression technique, it is observed in the literature that the 3D evaluation methods seem to be more reliable and accurate, showing in 3 dimensions where the imprecision of the impression technique is^{10, 28, 32}, unlike assessment methods that use two-dimensional measures that fail to assess inaccuracies in all dimensions and can often not be detected. Therefore, must prioritize in the present study the results found when using the 3D evaluation method (in the X, Y and Z axes) of the casts obtained from touch scanning.

Clinically, during the impression, several other factors may influence the quality of the impression that were not verified in the present study because it is *in vitro*, such as: presence of saliva, higher oral cavity temperature, muscle strains, impression material in certain regions, impression performed with the patient in occlusion. Therefore, clinical studies should be performed to evaluate the significance of the results obtained in the present study, as well as whether the differences found will influence implant / prosthesis survival.

CONCLUSION

Within the limitations of the present study, it can be concluded that:

- There was no statistically significant difference between the groups using the values of global marginal misalignment between the metallic infrastructure and the analogs;

- And in the 3D analysis by analogs, for the multifunctional guide impression, the bonding technique of the transfers with metallic rods presents better results for analog C;

- The bonding of the transfers with metal and acrylic resin presented better results than the bond with acrylic resin only for the MPM and GMR groups in the Z axis and in the combination between the XZ axes;

- The methods of evaluation of the precision of the technique of impression used in the present study presented different results between them.

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TABLES

Table 1 – Division of the experimental groups of this study.

Groups	Type of impression	Bonding techniques for transfers
GMM	Multifunctional guide	Metal + Resin
GMR	Multifunctional guide	Resin
MPM	Plastic tray	Metal + Resin
MPR	Plastic tray	Resin
MMM	Metallic tray	Metal + Resin
MMR	Plastic tray	Resin

Source: Own elaboration.

Table 2 - Median values of global misalignment (in μm) between the metallic infrastructure and analogs.

Groups	Misalignment
MM	142.8
GMM	181.18
GMR	99.22
MPM	139.55
MPR	134.36
MMM	163.06
MMR	154.55

Median values of global marginal misalignment (in μm) between the metallic infrastructure and analogs. $H = 11.0472$; Degrees of Freedom = 5; $p = 0.0505$

Source: Own elaboration.

Table 3 - Mean of the difference (in μm) of the analogs (A, B, C and D) in relation to the Z axis between the gypsum casts and the master cast.

Group	Mean	
GMM	563	AB
GMR	772	B
MPM	487	A
MPR	615	AB
MMM	531	AB
MMR	681	AB

Equal letters indicate statistical equality ($p > 0.05$).

Source: Own elaboration.

Table 4 - Mean of the difference (in μm) of the analogs (A, B, C and D) with respect to the XZ axis between the experimental casts and the master cast.

Group	Mean	
GMM	1061	AB
GMR	1380	B
MPM	888	A
MPR	1110	AB
MMM	934	AB
MMR	1280	AB

Equal letters indicate statistical equality ($p > 0.05$).

Source: Own elaboration.

Table 5 - Mean of the difference (in μm) in the X, Y and Z axes in relation to analog C between the experimental casts and the master cast.

Group	Mean	
GMM	302	A
GMR	492	B
MPM	315	AB
MPR	396	AB
MMM	366	AB
MMR	436	AB

Equal letters indicate statistical equality ($p > 0.05$).

Source: Own elaboration.

LEGENDS FOR ILLUSTRATIONS

Fig. 1 – Master cast and the passive metallic bar.



Fig. 2 – Experimental cast was obtained with different impression techniques.



Fig. 3 – Method of vertical misalignments (cervical adaptation)

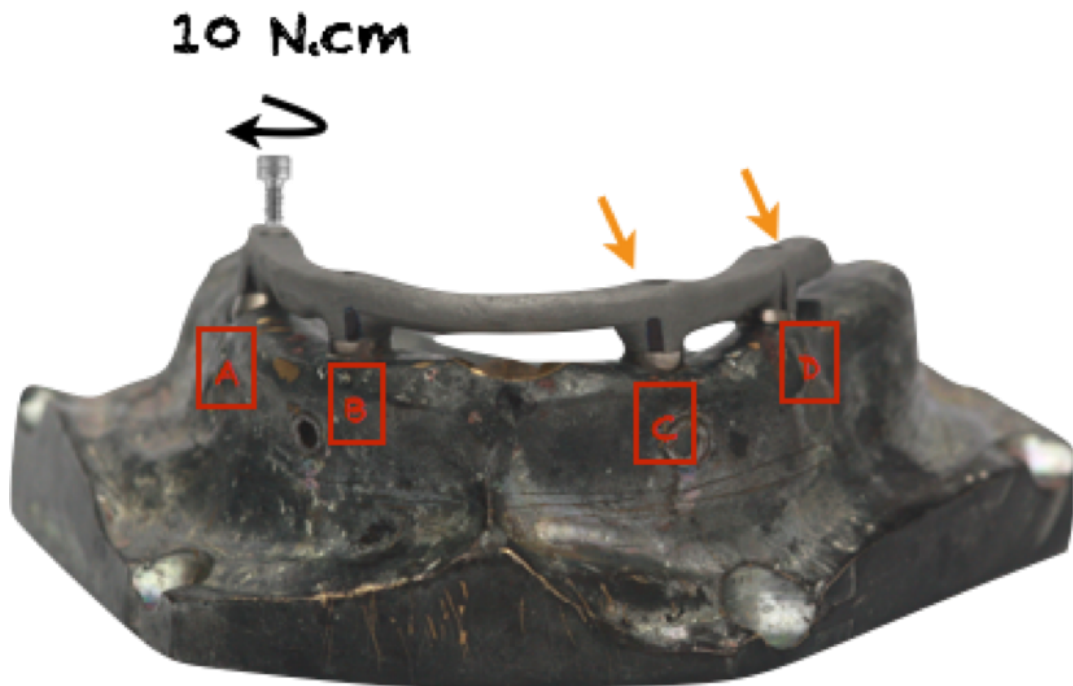


Fig. 4 – Registration of the misfit

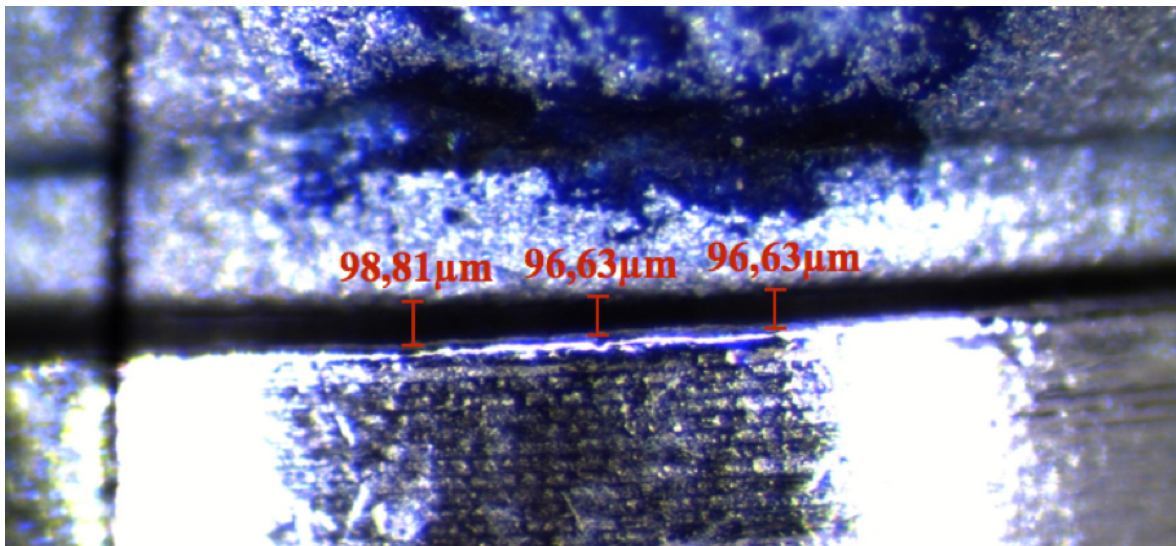
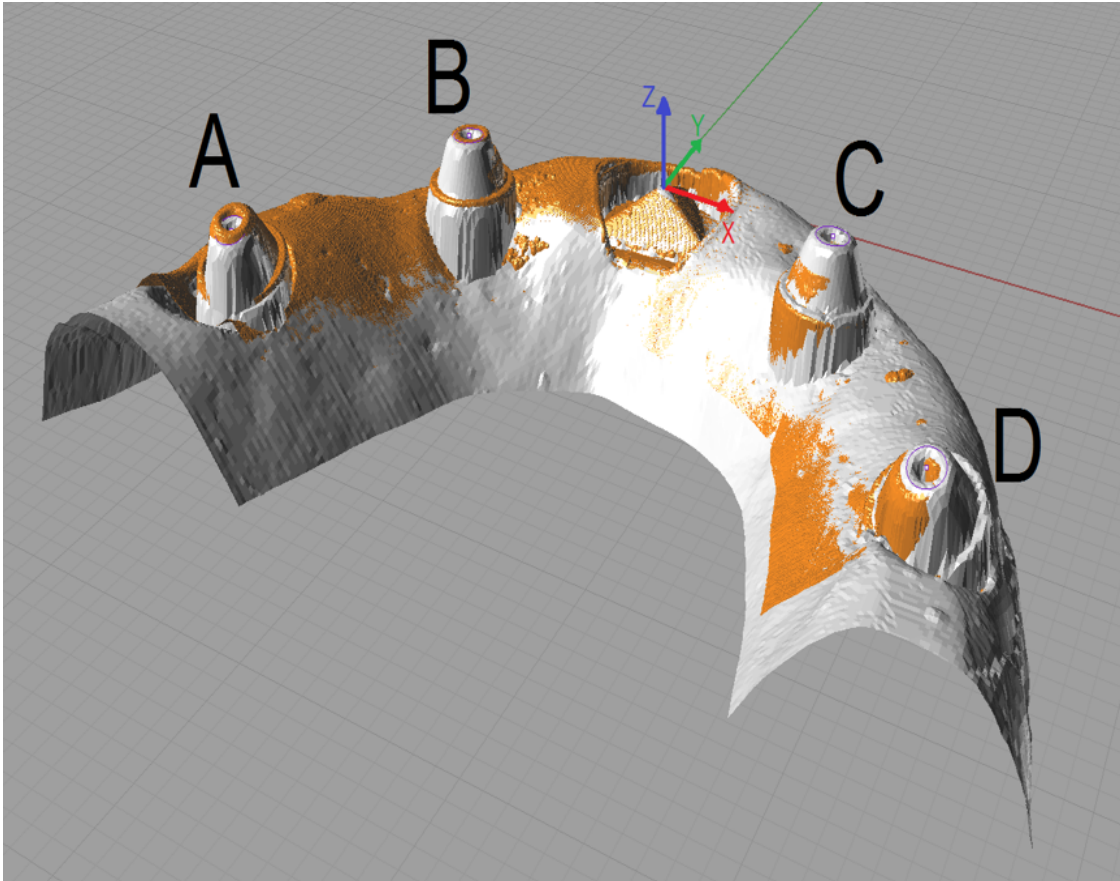


Fig. 5 – Overlap of the experimental cast image and the master cast image that was obtained by 3D touch scanning (X, Y and Z axis)



3.2 Artigo 2*

Accuracy of implant impression techniques in the maxilla “All-on-four scheme”: 2D and 3D analyses

Running title: Accuracy of different implant impressions: 2D and 3D analyses

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* Este artigo segue as normas do periódico (Clinical Oral Investigations) o qual foi submetido e está em revisão.

Accuracy of implant impression techniques in the maxilla “All-on-four scheme”: 2D and 3D analyses

ABSTRACT

Statement of problem: Getting a passive fit in an implant-supported prosthesis is primordial to have success, mainly in a “all-on-four scheme”.

Purpose: The aim of the present study was to analyze *in vitro* the accuracy of different implants impression with multifunctional guides simulating rehabilitation based on the All-on-4 scheme.

Material and methods: Six impression techniques were evaluated: Palate coverage multifunctional guide / metal and acrylic resin splint transfers (PM); Palate coverage multifunctional guide / acrylic resin splinted transfers (PR); Palate coverage multifunctional / without splint transfers (PC); Open palate multifunctional guide / metal and acrylic resin splint transfers (OM); Open palate multifunctional guide / metal and acrylic resin splint transfers (OR) and Open palate multifunctional guide / without splint transfers (OC). All the impression were made with polyvinyl siloxane impression material. Two methods of evaluation were used: measurement of vertical misfits (cervical adaptation) with a passive metal structure fabricated on the master cast (MM) and 3D evaluation of the overlap of digital images obtained by contact scanning. After verification of distribution and homoscedasticity data, statistical methods ($\alpha = 0.05$) were used to verify the influence of the independent variables.

Results: For the evaluation of vertical misfit, statistical differences were found only for the OM group (203.04 μm) when compared to the PR group (151.61 μm) and to the MM group (142.78 μm). In the 3D evaluation, no difference was found between the groups when the three axis (x, y and z) were analyzed together. However, when separating the analysis insulation by axis, difference was found between PM (214 μm) and OC (355 μm) for the X axis. For the Y axis, the PR (188 μm) was significant difference than the OM (538 μm).

Conclusion: The group OM, in the vertical misfit method evaluation, produced less accurate casts than the groups PR and MM. In 3D evaluation, PM had better results than the OC for the X axis. For the Y axis, the PR was more accurate than the OM. When

evaluating all axes together (X, Y and Z), all groups (OM, OR, OC, PM, PR, PC) produces casts with similar accuracy.

Clinical implications: The different techniques of splint transfers using multifunctional guides (palate coverage and open palate) produced similar accuracy casts when polyvinyl siloxane impression material was used. There was no difference between the impression techniques with splinted transfers when compared with the techniques without splinted transfers in 2D and 3D analyses.

Keywords: Dental implant. Dental prosthesis. Dental materials.

INTRODUCTION

Clinical or laboratory procedures have a direct influence on the final result of the oral rehabilitation with implants. Minimization of errors accumulated in these procedures can improve the longevity of treatments. Getting a passive fit in an implant-supported prosthesis is primordial to have success because this type of rehabilitation transmits the mechanical stresses directly to the peri-implant tissues.^{1, 2}

A precise work cast with regard to the position of the implants and adjacent structures in the oral cavity is essential for a proper fit between the prosthetic components. The presence of dimensional inaccuracy in the transfer of positioning of the implants or their abutments to the work casts can lead to unsatisfactory results or total failure of the prosthesis³. The accuracy of the work cast depends on the materials and techniques used for the impression and casting. Therefore, recent studies have been developed to produce more accurate and reliable work casts in the rehabilitation of implant-supported dentures, which can result in more adapted prostheses⁴⁻⁶. The reliability of the measuring system is vital to evaluate the accuracy of the impression. Because distortion of an impression can occur in the X, Y, and Z axes, its of paramount importance to analyze the distortion in three dimensions^{3, 7}.

The impression techniques using direct transfers (splinted or not) produce more accurate casts^{6, 8}. Some authors suggest that splinting techniques to connect all transfers using an acrylic resin bar can prevent individual transfer movement during the impression procedure⁹. On the other hand, the splinting material could distort due to residual

polymerization shrinkage¹⁰. Therefore, the efficacy of these techniques in yielding accurate molds is still controversial¹¹⁻¹³.

The multifunctional guide that was produced planning the position of the teeth in the mouth for implant placement could be used as an impression tray to facilitate the impression and the record of vertical dimension^{14, 15}. Two designs are widely used, one with a coverage palate and another with an open palate. The multifunctional guides with an open palate are less rigid than the multifunctional guides with a coverage palate, which can worsen the final result of the impression, as observed when comparing the quality of the impression with a plastic tray and with a rigid tray¹⁶.

However, little research has been done comparing the different splinting methods with different designs of multifunctional guides. Due to the importance of passive fit in the success of prosthetic implant rehabilitation and considering that the guide may influence the accuracy of the mold, the purpose of the present study was to compare *in vitro* the accuracy (2D e 3D) of casts produced by three different impression techniques with two types of multifunctional guides (palate coverage and open palate).

MATERIAL AND METHODS

- Master cast and reference framework

A reference metal cast was obtained from an edentulous maxilla cast by the lost wax casting technique. Perforations were performed and four implants with regular platform and external hex (Conexão – Sistemas de Próteses) were placed. Two implants (3.75 X 13 mm) were placed parallel to each other at the premaxilla area, while the other two (3.75 X 15 mm) were placed posterior to the canine fossa with angulation of 45°, simulating rehabilitation based on the *All-on-four* scheme. Micro-Unit abutments (Conexão – Sistemas de Próteses), presenting 3 mm collar and 30° angulation were screwed with 20N.cm torque. A framework was waxed over prefabricated Cr-Co plastic cylinders and a reference Cr-Co metal framework was obtained.

After the fabrication of the master framework, the original implants/abutments were removed, and new implants/abutments (Conexão – Sistemas de Próteses) were screwed into the framework copings with the aid of a calibrated torque wrench (Conexão – Sistemas de Próteses) limited to 10 N.cm. The new implants/abutments were then

embedded into the master cast holes with epoxy resin GY 1109/943 (Hunstsman). This produced a cast with implants with a passive fitting metal framework. This framework was the standard for the assessment of all subsequent measurements made to determine the accuracy of casts produced from different impression procedures.

- Multifunctional guides for impression trays

Two designs of the multifunctional guides to be used as a tray with an internal space thickness of 2.5 mm were made: one with palate coverage and the other with open palate. The multifunctional guides were designed virtually (Computer Assisted Design; Rhino3D, Rhinoceros) from the image obtained by the contact Scanner (MDX-40, Roland, Information Technology Center - CTI) of the metal cast. Both designed guides were produced by an additive manufacturing machine based on the PolyJet technology (Stratasys brand, Objet350 Connex model).

The variables assessed in the present study were the method of fixation of transfers and the type of multifunctional prototyped guide (palate coverage or open palate) on the accuracy of impression.

For all groups described, Express XT (3M/ESPE) polyvinyl siloxane impression material was used. The putty material was mixed according to the manufacturer's instructions, and the regular body was prepared with an automix-dispenser (3M/ESPE). Eight impressions were performed for each group.

For all groups, with the guide positioned on the metal cast, the regular body polyvinyl siloxane was injected over the implant surrounding areas with the aid of a dispenser, while the heavy body was inserted into the multifunctional prototyped guide and pushed with digital pressure through the opening present in the guide. All procedures were performed under controlled room temperature ($23^{\circ}\text{C} \pm 2^{\circ}\text{C}$) and humidity ($50\% \pm 10\%$).

- Impression techniques

Six impression techniques were employed as follows:

- PC Group: Impression with a multifunctional guide with palate coverage and without splinted transfers. Squared transfers were screwed in the reference metal cast with a 1.17 external hex driver until resistance was noticed. Transfers were then screwed

with a manual torque wrench with 10 N.cm¹⁷. The impression was performed with a multifunctional prototyped guide with palate (Fig. 1 – A).

- OC Group: Impression with multifunctional guide with open palate and without splinted transfers. Transfers were placed following the same steps described for the PC group, but the impression was performed with a multifunctional prototyped guide without palate (Fig. 1 – B).

- PM Group: Impression with multifunctional guide with palate coverage and with metal splinted transfers. Transfers were placed following the same steps described for the PC group and they were fixed with a circular metal bar (2.3 mm in diameter) and cyanoacrylate (Super-Bonder – Loctite). Acrylic resin (PatternResin, GC America Inc.) was applied using the brush-on technique, fixing the metallic bars, transfers and the multifunctional guide prior to the impression procedure (Fig. 1 – C). The impression was performed with a multifunctional prototyped guide with palate.

- OM Group: Impression with a multifunctional guide with open palate and with metal splinted transfers. The same splinting procedures as in the PM group were performed. The impression was performed with a multifunctional prototyped guide without palate (Fig. 1 – D).

- PR Group: Impression with a multifunctional guide with a palate and with acrylic resin splinted transfers. Transfers were placed following the same steps described for the PC group and they were fixed with prefabricated acrylic resin bars (PatternResin, GC America Inc.)¹⁷ through the injection of the resin in drinking straws with 2 mm diameters. The joining process was started by placing auto polymerizing acrylic resin around the retentive area of the modified square transfers. Appropriate bar sizes were cut with a double edged diamond blade to fill the spaces between the transfers, and with the brush technique, the ends of the bars were attached to the transfers, finalizing the bonding. After polymerization, a space was created by cutting the acrylic resin bars with a double edged diamond blade with the purpose of minimizing the forces caused by the contraction of the resin. After cutting, the bars were attached again with acrylic resin with the brush technique and the set was attached to the guide with acrylic resin (Fig. 1 – E). The impression was performed with a multifunctional prototyped guide with a palate.

- OR Group: Impression with a multifunctional prototyped guide without a palate and with acrylic resin splinted transfers. The same splinting procedures as in the PR group were performed. The impression was performed with a multifunctional prototyped guide without a palate (Fig. 1 – F).

After the impression material setting, transfers screws were loosened and the impression and reference metal cast were separated. Analogs were then attached to the transfers prior to the fabrication of casts.

- Fabrication of casts

The impression and cast fabrication procedures were performed by the same operator, who was not the researcher responsible for the framework fitting measurements. A mold base former was used to standardize the casts according to the amount of stone employed. Two hours passed the impression material setting, and type IV stone (Fuji Rock EP - GC) was mechanically mixed under vacuum (EDG Equipamentos) for 30 seconds following the manufacturer's instructions and poured into the impression in small portions. After 60 minutes, the casts were separated and stored at room temperature for 120 hours (ADA, 25). A total of 8 casts were obtained in each group, being 48 casts in total.

- Measurement of vertical misalignments (cervical adaptation)

The metal framework was seated on each cast and a titanium screw was tightened in analog A to 10 N.cm using a torque driver, while measurements of abutment-framework interface gaps were made in analogs C and D (Fig. 2).

This process was repeated for analog D, and the measurements of analogs A and B were recorded^{18, 19}. For the measurements, image of the analog/framework interface were taken with a video camera (JVC, 0,5-in. CCD, model TK-C1380, Tokyo, Japan) coupled to a Leica stereomicroscope (Leica Microsystems) at 100x magnification. The misalignment measurements were performed using software (Leica Imaging System). Vertical lines were made in the relative center of each abutment between the metallic structure and the analog implants to standardize the captured image. For each picture taken, the lineal reading of the gap was done in 3 different regions (one measurement in the distal, one in the middle and one in the mesial). The arithmetic mean of these three values determined as the value of the gap. The mean gap value for the cast was

calculated as the average of three consecutive measurements and the framework was screwed before each measurement. The same researcher performed all procedures.

- 3D evaluation of the overlap of digital images obtained by contact scanning

For digitalization of the master cast, an industrial contact scanner (MDX-40, Roland) previously calibrated in 0.2 mm for the contact probe over the scanned surface was used. The scanner created one digital cast, posteriorly used as a control image. Next, all the casts created with different transfer impression techniques were also digitalized with the contact scanner for posterior comparison with the scanner's images to evaluate the accuracy between the impression techniques.

A CAD software (Computer Assisted Design; Rhino3D, Rhinoceros, USA) was used to superimpose the STL images of each group onto the reference STL (industrial scanner). Initially, one image was imported to the program to select the points and construction of references for orientation and measurement of the distances between the pyramid and each abutment. Posteriorly, creation of plans for the representation of the pyramidal geometry and obtaining of the edges and peak of the pyramid were created. Once the reference points were obtained, the STL of the reference cast was imported into the Bio-CAD program by repeating the previously described steps to allow subsequent orientation of the pyramid references of the image to be analyzed in relation to the reference cast image. The peak of the pyramid was used as the origin of the coordinate systems of the casts to obtain the distances between the origin and the centers of the abutments (Fig. 3). Measurements were made on the three axes of the pyramid: X (lateral deviations), Y (anteroposterior deviations) and Z (vertical deviations), as can be seen in Fig. 4, obtaining three measurements for each component (Fig. 5).

- Statistical analyses

From the data obtained and with the aid of the SigmaStat version 3.11 program (Systat Software, Inc.) the results were analyzed statistically to establish the conclusions. Normality test and equality of variance were made to decide the best statistical test to be used for each comparison to be made.

RESULTS

-Measurement of vertical misfits (cervical adaptation)

The results showed that there were significant differences among groups. For this reason, the Dunn's Method post test (Table 1) was used to perform multiple comparisons between groups. Compared to the control group, the best technique is the PR (151.61 μm), the worst is the OM (203.04 μm) and the others are in intermediate positions, being statistically equal at the same time to the PR (151.61 μm) and OM (204.04 μm) (Table1).

- 3D evaluation of the overlap of digital images obtained by contact scanning

X, Y and Z axes: There was no statistically significant difference between the groups for the combination of the XYZ axes (Table 2).

X axis: There was a statistically significant difference between the groups ($p = 0.016$) – one way ANOVA and Tukey's test (Table 3).

Y axis: There was a statistically significant difference between the groups ($p = 0.022$) - Kruskal-Wallis and Dunns. (Failure of normality) (Table 4).

Z axis: There was a statistically significant difference between groups ($p = 0.001$) - one-way ANOVA and Tukey's (Table 5).

DISCUSSION

Many variables can interfere in the adaptation of the infrastructure to implants in oral rehabilitation with this type of prosthesis, such as: the type of impression material, the amount of plaster used to pour the mold, the angle of the implants, the method of splintering transfers, the use of different types of trays (plastic tray, metal tray and multifunctional guide), and others factors^{11, 16, 20}. For these reasons, some variables were controlled in the present study: the use of standard quantities of plaster molds during casting, using a single impression material and using multifunctional prototype guides like a tray, ensuring the standardization of the impressions.

Many authors suggest to use splinted transfers in impression implants to prevent rotational movements inside the mold when the analog is screwing, ensuring that the transfer dies are maintained in position within the mold, resulting in more accurate casts^{5, 6, 21}. However, this is a controversial point in the literature, some studies^{22, 23} could not find differences between impression with and without splinted transfers, as well as in the present study where there was no difference between the splinted techniques (OM, OR,

PM and PR) when compared with the techniques without bonding (OC and PC), both in the method of evaluation measurement of vertical misalignments (cervical adaptation) and in the three-dimensional evaluation (3D evaluation of the overlap of digital images obtained by contact scanning). This can be explained by the fact that in the present study, only polyvinyl siloxane was used (in the regular and putty consistency) as impression material, which is considered more stable and accurate than any other impression material²⁴, being responsible for stabilizing the transfers into the mold, generating casts with similar results.

One of the main factors that can affect the quality of an impression using splinted transfers is the contraction polymerization of the acrylic resin used for this bond. A larger amount of acrylic resin used at once can lead to higher contraction during polymerization²⁵, one reason which explains why the Palate Coverage / Resin splint (PR) impression technique was statistically more accurate than the Open palate / Metal splint (OM) technique in the 2D evaluation (cervical adaptation) and in the 3D evaluation. We also found this result for the Y axis (anteroposterior) and the PR (188 μm) was more accurate than the OM (538 μm). Moreover, in the OM group, the resin bars cut was not made to minimize the stresses caused by the contraction polymerization of the acrylic resin, so the quantity of acrylic resin polymerizing together is larger than the of PR group, generating a less accurate cast.

In the three-dimensional evaluation for the X axis (Lateral), it was observed that the Palate Coverage / Metal splint PM (214 μm) group presented better results than the Open Palate / Without splint OC (355 μm) group. The rigidity of the multifunctional guide may have influenced the accuracy of the molding, since the palate coverage multifunctional guide was superior to the open palate multifunctional guide in the X axis for the PM and OC groups, results also found in Del'Acqua¹⁶ et al. (2012) study in that the greater rigidity of the tray positively influenced the quality of the mold. Another factor that explains this result is that the rigid bonding of the transfers presents better results than the bond, such a condition is proven in several studies.

Moreover, marginal leakage of implant-supported prosthesis must be clinically up to 100 microns²⁶. In the present study, the median of marginal leakage of the master cast is around 142.78 microns, and higher values of marginal leakage was observed in the

tested groups. These higher values of marginal leakage observed are also higher than those expected clinically²⁶, and can be explained by: the micrometric inaccuracies inherent in the turning process of prosthetic components, the measurement method used in the study (screw the framework in analog A and the measurements made in contralateral analogs amplifies the values of the misalignments) and because the measurements of the experimental casts are made with a framework that was already a considerable marginal misalignment in the master cast.

In the three-dimensional evaluation for the Z axis (vertical), the Palate coverage / Without splint PC (354 μm) and Open palate / Without splint OC (325 μm) groups presented better results than the Open palate / Metal splint OM group (587 μm) which may be explained by the fact that less stress was generated in the mold during the insertion of putty molding material, since the transfers were not bonded together. In the OM group, the putty material during its insertion may have generated a tension in the set (transfers bonded together and attached to the multifunctional guide), reducing the precision of this technique for the Z axis. We must remember that the present study was performed *in vitro*, so we had no influence of the mouth muscles and other clinical hinderences, and the operator was trained and calibrated, making the impressions and screwing of the analogs in the mold with extreme care and all the impressions were made with a high precision material (polyvinyl siloxane) in putty and regular consistency. So, the non-union of the transfers did not affect the precision of the molds, which many studies report to be less precise^{6, 10, 27}. Despite the difference in the Z axis (vertical), there was no significant difference in the three-dimensional evaluation when all analogs and axes were analyzed at the same time, corroborating with results founded in other studies¹¹⁻¹³.

When comparing the methods to evaluate the accuracy of the molding technique, it is observed in the literature that the 3D evaluation methods seem to be more reliable and accurate, showing in 3 dimensions where the imprecision of the molding technique is, unlike assessment methods that use two-dimensional measures that fail to assess.

CONCLUSION

Within the limitations of the present study, it was concluded that:

- There was no difference between the impression techniques with splinted transfers (OM, OR, PM and PR) when compared with the techniques without splinted transfers (OC and PC) in 2D and 3D analyses.

- The Palate Coverage / Resin splint (PR) impression technique resulted in more accurate casts than the Open palate / Metal splint (OM) technique for measurement of vertical misalignment (cervical adaptation) analyses.

- For the Y (anteroposterior) axis in the 3D analyses, the Palate Coverage / Resin splint (PR) generated more accurate casts than the Open palate / Metal splint (OM).

- For the X (lateral) axis in the 3D analyses, the Palate Coverage / Metal splint (PM) group generated more accurate casts than the Open Palate / Without splint (OC) group.

- For the Z (vertical) axis in the 3D analyses, the Palate Coverage / Without splint (PC) and the Open Palate / Without splint (OC) groups presented better results than the Open Palate / Metal splint (OM) group.

- When evaluating all axes together (X, Y and Z), all groups (OM, OR, OC, PM, PR, PC) produces casts with similar accuracy.

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TABLES

Table 1 – Median marginal gap (μm) and Kruskal-Wallis test results.

Group	Median	
MM	142.78	B
OC	162.51	AB
PC	201.96	AB
OR	163.23	AB
PR	151.61	B
OM	203.04	A
PM	194.18	AB
p	<0,001	

Same letters indicate statistical equality among rows ($p \geq 0.05$).

Source: Own elaboration.

Table 2 - Median of the global difference (μm) values (X, Y and Z axis of the A, B, C and D analogs) of the experimental groups in relation to the master cast, Araraquara, 2019.

Group	Median	
PC	883	A
PM	924	A
PR	1.025	A
OC	942	A
OM	1.393	A
OR	1.059	A

Source: Own elaboration.

Table 3 - Mean of the difference (μm) of the analogs in relation to the X axis between the experimental casts and the master cast.

Group	Median	
PC	264	AB
PM	214	A
PR	275	AB
OC	355	B
OM	379	AB
OR	313	AB

Equal letters indicate statistical equality ($p > 0.05$)

Source: Own elaboration.

Table 4 - Median of the difference (μm) of the analogs in relation to the Y axis between the experimental casts and the master cast.

Group	Median	
PC	278	AB
PM	271	AB
PR	188	A
OC	307	AB
OM	538	B
OR	294	AB

Equal letters indicate statistical equality ($p > 0.05$)

Source: Own elaboration.

Table 5 - Mean of the difference (μm) of the analogs in relation to the Z axis between the experimental casts and the master casts.

Group	Median	
PC	354	A
PM	429	AB
PR	497	AB
OC	325	A
OM	587	B
OR	504	AB

Equal letters indicate statistical equality ($p > 0.05$)

Source: Own elaboration.

LEGENDS FOR ILLUSTRATIONS

Fig. 1 – Illustration of all impression techniques. A – PC Group; B – OC Group; C – PM Group; D – OM; E – PR Group; F – OR Group.

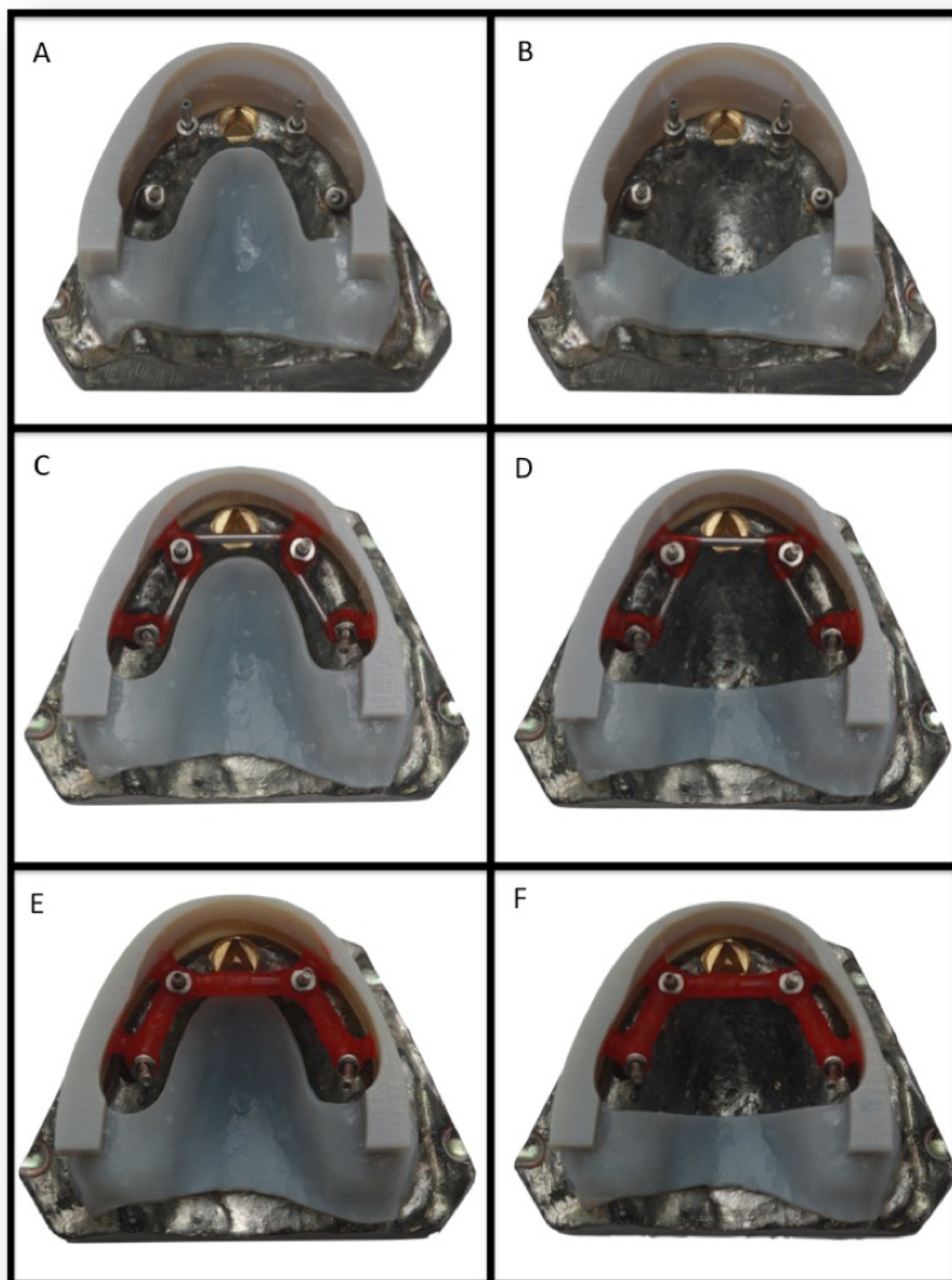


Fig. 2 – Master cast with the metallic framework and the method of vertical misalignments (cervical adaptation).

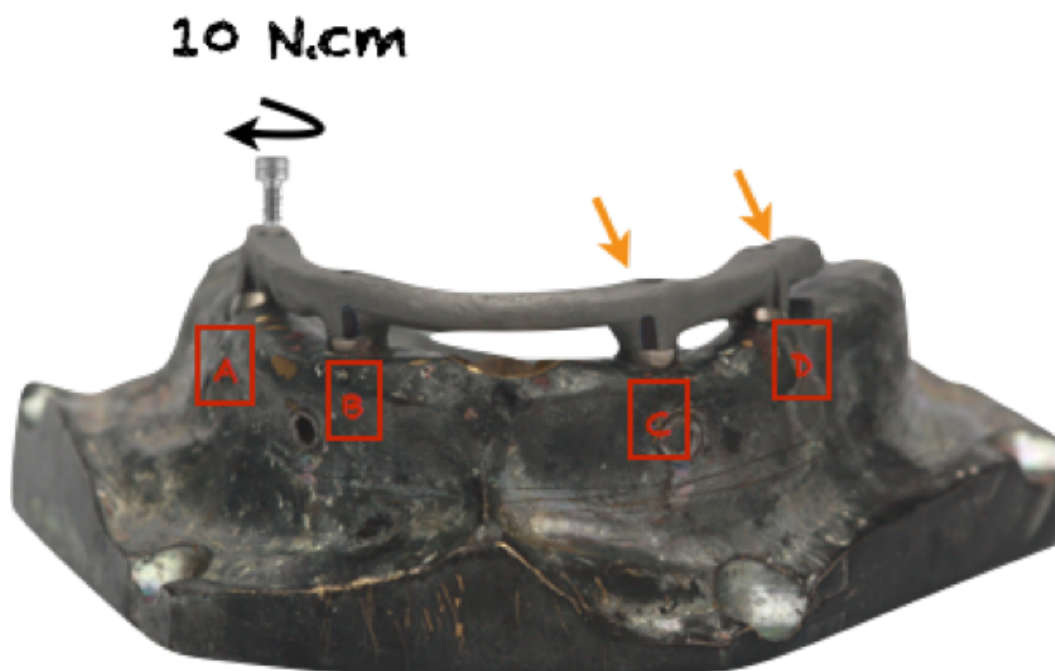


Fig. 3. - Selection of the points of interest and construction of references for overlapping the images.

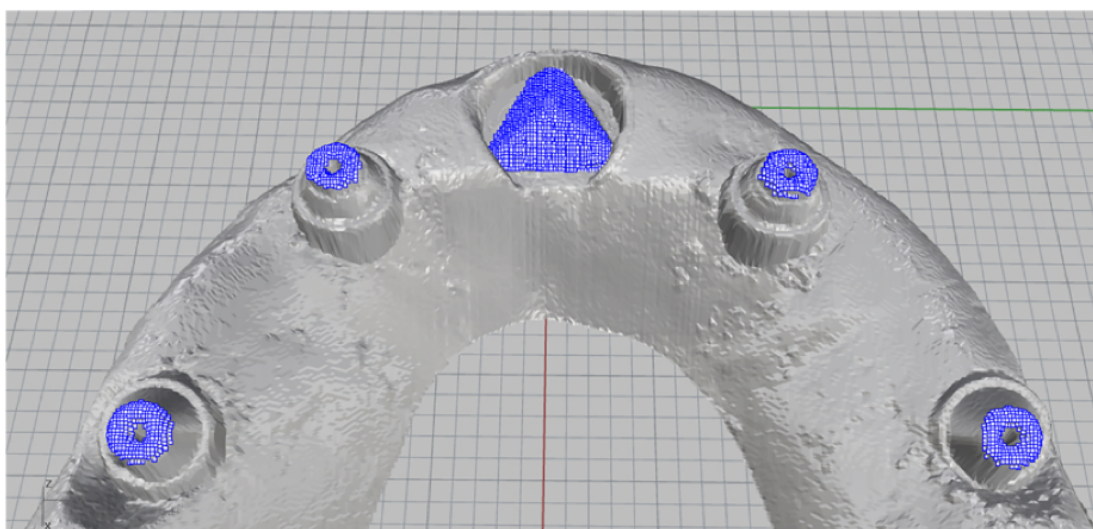


Fig. 4 - Origin of the coordinate systems of the models for measurements of the distances between the abutments and the peak of the pyramid

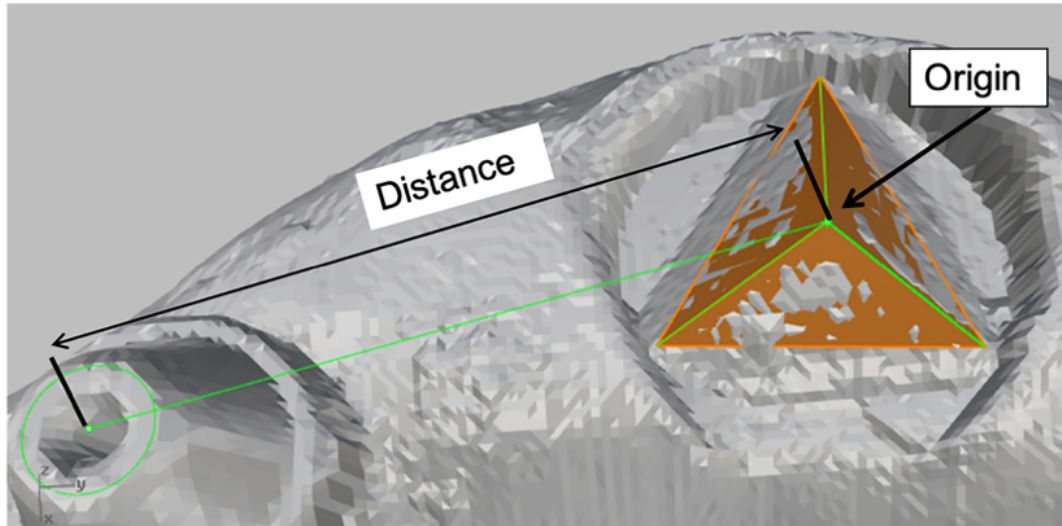
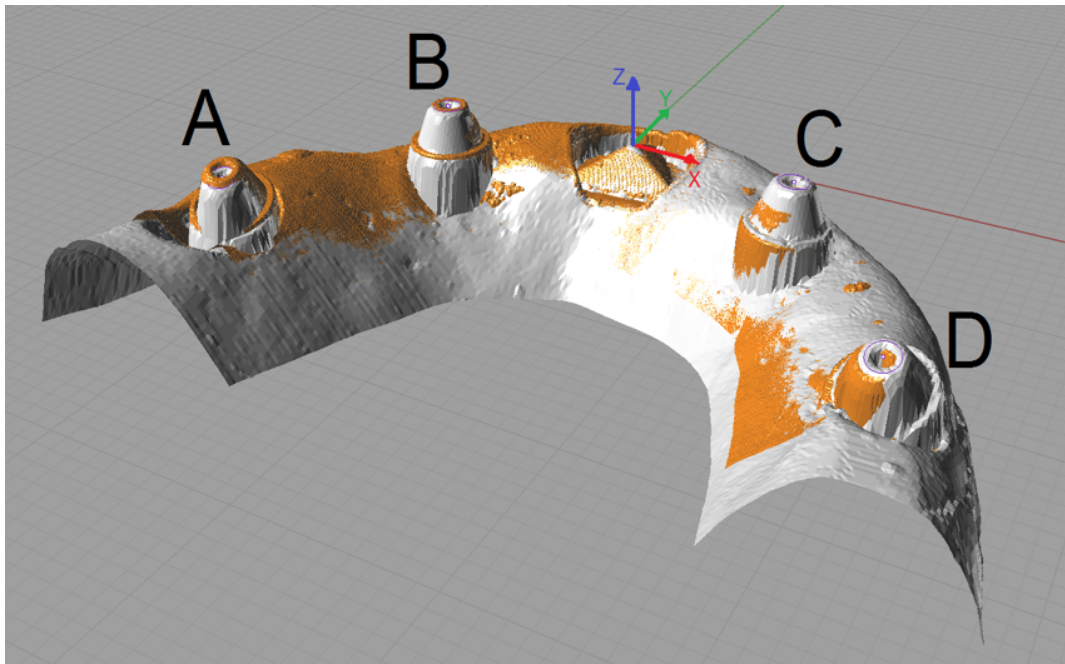


Fig. 5 – Axes X, Y and Z



4 CONCLUSÃO

Dentro das limitações do presente estudo, pode-se concluir que:

- Não houve diferença estatisticamente significativa entre os grupos (GMM, GMR, MPM, MPR, MMM e MMR) utilizando os valores de desadaptação marginal global entre infraestrutura metálica e análogos/ e na análise 3D dos três eixos juntos (X, Y e Z);
- A união dos transferentes com metal e resina acrílica apresentou melhores resultados do que a união apenas com resina acrílica para os grupos MPM e GMR no eixo Z e na combinação entre os eixos XZ. Na análise global 3D por análogos a moldagem com guia multifuncional (GMM e GMR), a técnica de união dos transferentes com hastes metálicas apresentou melhores resultados;
- Não houve diferença estatisticamente significativa entre as técnicas de moldagem que utilizaram transferentes unidos (OM, OR, PM e PR) quando comparado com as técnicas de moldagem sem união dos transferentes (OC e PC) utilizando os valores de desadaptação marginal global entre infraestrutura metálica e análogos/ análise 3D dos três eixos juntos (X, Y e Z);
- A técnica de moldagem (PR) produziu modelos mais precisos do que a técnica OM na avaliação valores de desadaptação marginal global entre infraestrutura metálica e análogos. Na avaliação global dos três eixos juntos (X, Y e Z), todos os grupos (OM, OR, OC, PM, PR, PC) produziram modelos com precisão similar;
- Na análise 3D, no eixo Y a técnica de moldagem PR gerou modelos mais precisos em comparação com a técnica OM. Para o eixo X, a técnica PM foi superior a técnica OC. E no eixo Z, as técnicas de moldagens PC e OC produziram modelos mais precisos que a técnica OM;

- Os métodos de avaliação da precisão da técnica de moldagem utilizados no presente estudo apresentaram resultados diferentes entre si.

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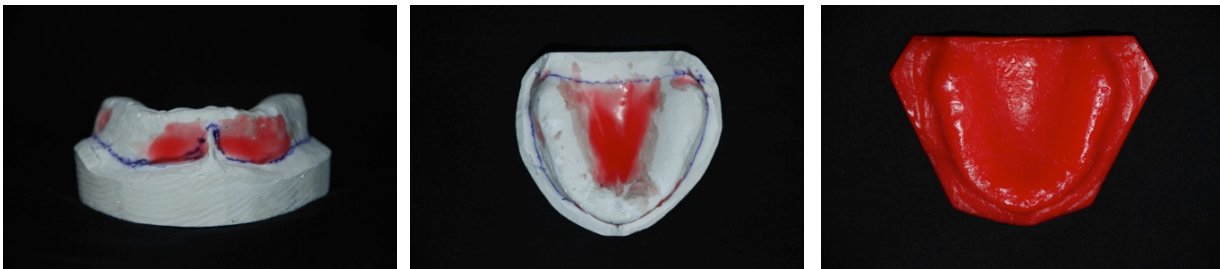
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APÊNDICE A - Metodologia detalhada

Confecção do Modelo Mestre

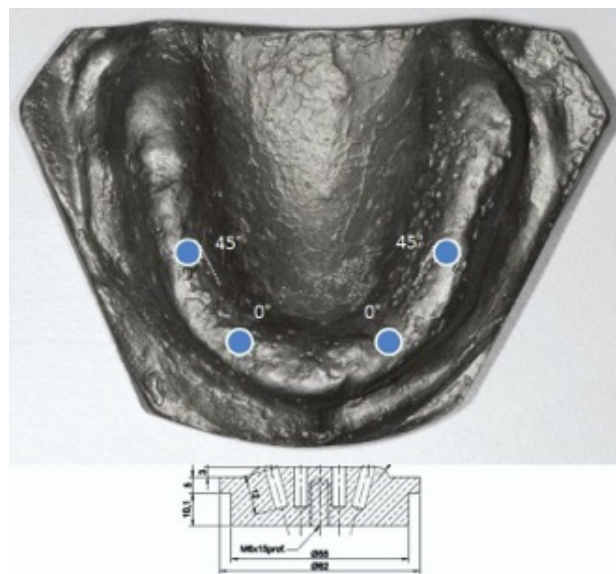
Foi obtida uma matriz metálica (Figura 2 e 3) a partir de um modelo de maxilla desdentada (Figura 1), pela técnica de fundição por cera perdida, onde foram realizadas perfurações de 4.1 mm em torno mecânico de precisão e instalados implantes de plataforma regular e hexágono externo (Conexão – São Paulo - Brasil), sendo duas perfurações paralelas na região de pré-maxila e duas anguladas em 45° na região posterior à fossa canina (simulando uma reabilitação fundamentada no conceito “All-on-4”).

Figura 1 – Modelo de maxila duplicado e réplica em cera para inclusão



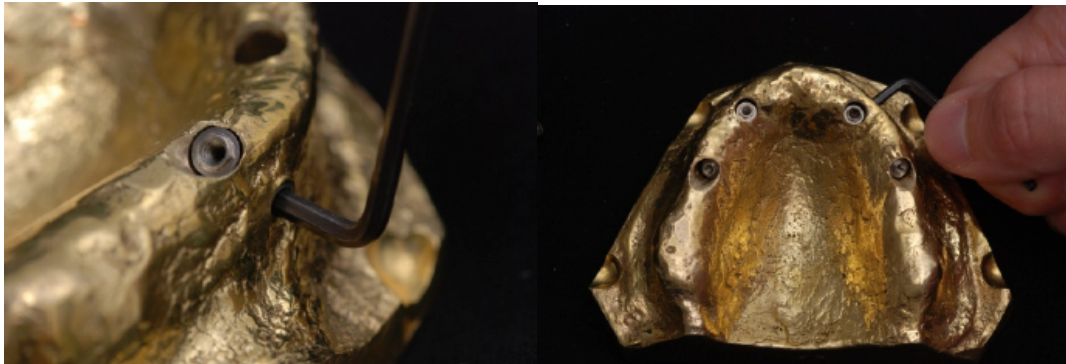
Fonte: Elaboração própria.

Figura 2 - Esquema do modelo anatômico. Vista em perspectiva das inclinações dos implantes.



Fonte: Elaboração própria.

Figura 3 – Modelo metálico, vista oclusal, implantes posicionados e fixados lateralmente com parafuso Allen.



Fonte: Elaboração própria.

Sobre os implantes anteriores de 13 mm de comprimento foram instalados intermediários (Micro-Unit) com cinta de 3 mm do mesmo sistema dos implantes (Conexão – São Paulo - Brasil), e sobre os implantes posteriores de 15 mm de comprimento foram instalados intermediários (Micro-Unit) com cinta 3 mm e angulados em 30°. Todos os intermediários receberam um torque de 20 N.cm conforme recomendado pelo fabricante (Figura 4). Sobre os componentes intermediários foi confeccionada uma estrutura metálica em Cr-Co. A barra foi encerada sobre cilindros calcináveis com base de Cr-Co pré-fabricados do mesmo sistema dos implantes (Figura 5). Após a obtenção da barra, o conjunto implante e intermediários (Micro-Unit) foram fixados à barra, e em seguida o conjunto foi cimentado nas perfurações do modelo metálico com resina epóxi de alta dureza GY 1109/943 (Hunstsman) e ainda parafusados lateralmente na altura do terço médio dos implantes, com parafuso do tipo Allen, para garantir o assentamento passivo da infraestrutura metálica e a estabilidade dos implantes.

Figura 4 – Mini pilares cônicos posicionados”.



Fonte: Elaboração própria.

Figura 5 – Infraestrutura metálica posicionada sobre os minipilares cônicos



Fonte: Elaboração própria.

Além disso, para a realização das análises 3D após escaneamento por contato, foi instalada uma como referência uma pirâmide de base triangular (Figura 6) para que a sobreposição das imagens escaneadas dos modelos dos grupos experimentais fosse realizada de modo padronizado.

Figura 6 – Modelo Mestre com pirâmide de base triangular para guiar a sobreposição das imagens escaneadas.



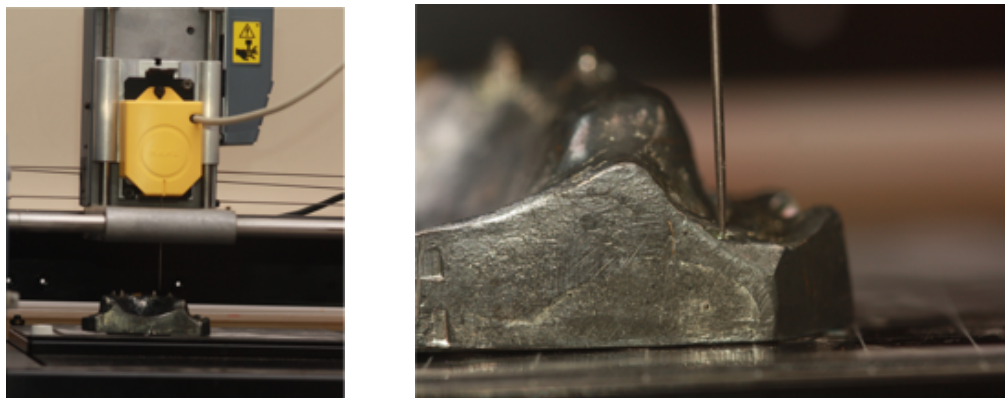
Fonte: Elaboração própria.

Moldagem

Para a realização das moldagens com as moldeiras perfuradas de plásticas No. 06 (Dental Morelli Ltda - Sorocaba, SP, Brasil) e perfuradas metálicas S4 (Moldeiras Tecnodent Indústria & Comércio - São Paulo, SP, Brasil) perfurações nas regiões dos implantes foram realizadas para passagem do parafuso passante dos transferentes quadrados para possibilitar o acesso ao parafuso após a moldagem.

Os guias multifuncionais prototipados utilizados como moldeiras de moldagem foram desenhados virtualmente a partir do escaneamento por toque do modelo mestre (matriz metálica) pelo Scanner de contato (MDX-40, Roland, Centro de Tecnologia da Informação - CTI, Campinas, SP, Brasil) calibrado em 0,2mm para cada traçado da ponta de contato sobre a superfície escaneada (Figura 7). A imagem gerada em arquivo *.STL a partir dos escaneamentos foi exportada para o programa Bio-CAD (Computer Assisted Desing; Rhino3D, Rhinoceros, USA) servindo de malha para ser feito o desenho virtual de dois tipos de guias multifuncionais (com palato e sem) com espessura padronizada de 2,5mm, simulando a conformação de um guia multifuncional utilizado clinicamente (Figura 8). Após o desenho virtual, esses guias foram confeccionados numa máquina de manufatura aditiva que funciona com tecnologia Polyjet, marca Stratasys, modelo Objet350 Connex. O equipamento trabalha com resinas fotopolimerizáveis, depositadas por cabeçote de múltiplos injetores.

Figura 7 – Escaneamento do modelo mestre pelo Scanner de contato.



Fonte: Elaboração própria.

Figura 8 – Tipos de guias multifuncionais (a, b) e moldeiras (c, d).



a – Guia multifuncional com palato



b - Guia multifuncional sem palato



c – Moldeira plástica



d - Moldeira metálica

Fonte: Elaboração própria.

O material de moldagem utilizado foi o silicone polimerizado por reação de adição Express XT (3M ESPE - Minesota - EUA), nas consistências densa e regular (Figura 9).

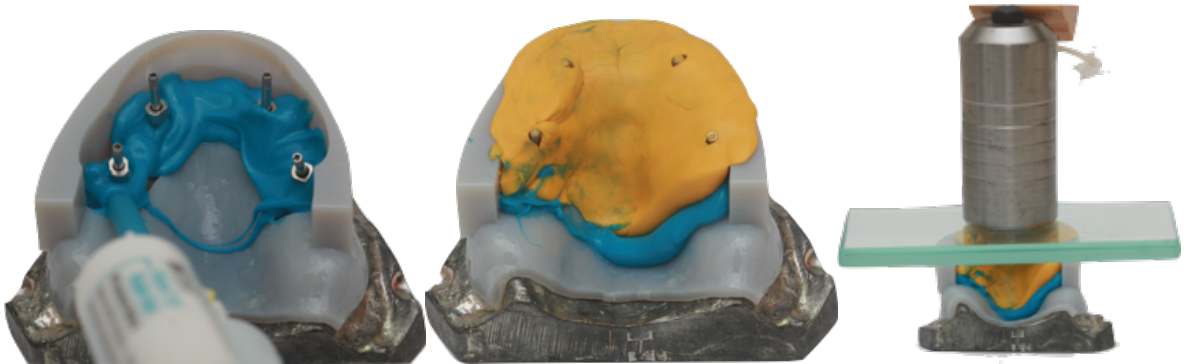
Figura 9 – Silicone de adição regular e densa utilizada para realizar as moldagens



Fonte: Elaboração própria.

O material denso foi proporcionado (uma porção de cada massa do silicone denso será pesado para ser utilizado a mesma quantidade de material em todas as moldagens) e manipulado seguindo as recomendações do fabricante. O silicone de adição regular foi manipulado em ponta de automistura acoplada em dispensador do próprio fabricante (a quantidade de material regular utilizado também foi padronizada para todas as moldagens, utilizando dois clicks do dispensador para cada moldagem). Os primeiros 3,0 cm dessa mistura foram dispensados, garantindo a homogeneidade do material. Devido à incompatibilidade do silicone de adição com o látex, os silicones densos foram manipulados manualmente por único operador calçando luvas de vinil. O silicone de consistência regular foi injetado na região de interesse (ao redor dos transferentes unido ao guia multifuncional) e em seguida o material denso foi inserido sobre o material regular com uma leve pressão digital para ajustar o material ao guia multifuncional. No caso da moldagem com moldeira, o material leve também foi injetado ao redor dos transferentes e o material pesado foi colocado na moldeira para realização da moldagem. Foi utilizado quantidades similares de material de moldagem para obtenção dos corpos de prova. Depois da moldagem, uma massa de 1kg foi colocado sobre o guia para padronizar a pressão em todos os moldes (Figura 10).

Figura 10 – Moldagem com guia multifuncional



Fonte: Elaboração própria.

Todos os procedimentos foram realizados com temperatura ambiente controlada ($23^{\circ}\text{C} \pm 2^{\circ}\text{C}$) e umidade relativa de $50\% \pm 10\%$. Após o tempo de polimerização do material (7 min), foi esperado duas horas, a fim compensar o retardo do tempo de polimerização e eliminação de produtos da reação por adição.

Técnicas de união dos Transferentes

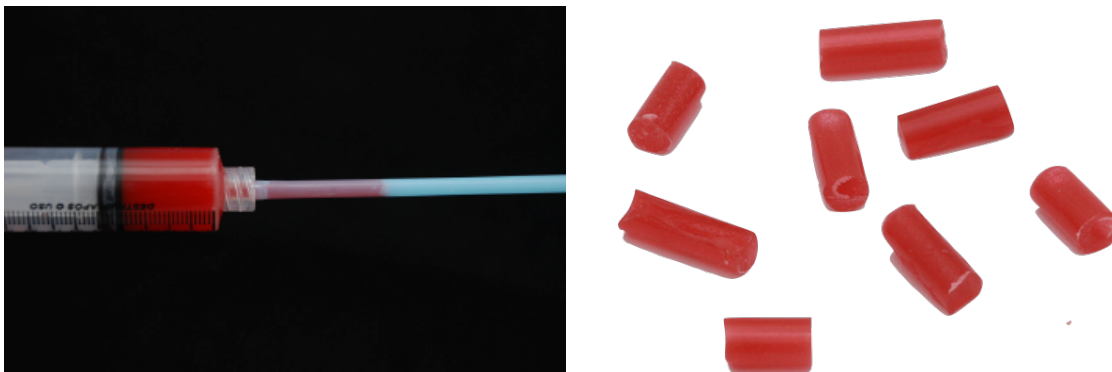
Os transferentes quadrados foram parafusados com a chave digital de hexágono interno de 1,17 mm até sentir-se resistência e então receberão um torque de 10 N.cm com um torquímetro protético para uma melhor padronização.

Foram utilizadas 3 diferentes técnicas de união dos transferentes:

- Transferentes quadrados unidos com resina acrílica (Pattern Resin, GC AmericaInc);
- Transferentes quadrados unidos com hastes de aço inoxidável e resina acrílica (Pattern Resin, GC AmericaInc);
- Transferentes quadrados sem união

Na técnica de união onde os Transferentes quadrados foram unidos com resina acrílica, foi inicialmente aplicada resina acrílica (Pattern Resin, GC AmericaInc) em volta da parte retentiva dos transferentes quadrados. Os cilindros de resina acrílica previamente fabricados foram seccionados em comprimentos apropriados para fechar o espaço entre os transferentes quadrados adjacentes (Figura 11).

Figura 11 – Produção dos bastões de resina



Fonte: Elaboração própria.

Usando a técnica do pincel, as extremidades dos cilindros de resina foram unidas aos transferentes. Foi aguardado um período de polimerização da resina de pelo menos 17 minutos antes de seu seccionamento e para realização de nova união. Foi padronizado apenas o espaço criado pelo corte do cilindro de resina com um disco diamantado de dupla face. Possibilitando uma minimização de tensões produzidas pela contração da resina. Após o corte, os cilindros foram unidos novamente com resina acrílica, e esperados outros 17 min para realização da moldagem (Figura 12). No caso da moldagem com guia multifuncional, os transferentes também foram unidos ao guia com resina acrílica.

Figura 12 – Método de união dos transferentes quadrados com resina acrílica



Fonte: Elaboração própria.

Para o método de união onde Transferentes quadrados foram unidos com hastes de aço inoxidável e resina acrílica, esses transferentes foram unidos entre si inicialmente com cilindros metálicos de aço inoxidável com diâmetro de 2,3 mm (simulando fragmentos de brocas) com cianoacrilato (Super-Bonder - Locitite). Posteriormente, esta união foi reforçada com resina acrílica (Pattern Resin, GC AmericanInc) pela técnica do pincel, e foi aguardado 17 min para realização da moldagem (Figura 13). No caso da moldagem com guia multifuncional, os transferentes também foram unidos ao guia com resina acrílica.

Figura 13 – Método de união dos transferentes quadrados com haste metálica, resina acrílica e cianoacrilato



Fonte: Elaboração própria.

Produção dos modelos

Os parafusos passantes dos transferentes foram afrouxados e em seguida o conjunto molde/modelo mestre separados, lembrando que foi realizado previamente uma calibração intra-operador para cada variável. No molde, os análogos foram aparafusados aos transferentes com chave digital de hexágono externo de 1,17 mm até sentir-se resistência e então submetidos a torque de 10 N.cm com torquímetro protético manual segurando o análogo com um porta agulha para evitar movimentação do transferente dentro do molde (Figura 14).

Figura 14 – Aspecto do molde e instalação dos análogos no mesmo



Fonte: Elaboração própria.

Após 2 (duas) horas da realização da moldagem, o gesso pedra tipo IV (Fuji Rock EP – América Inc - USA) foi espatulado mecanicamente à vácuo (EDG equipamentos – São Carlos – SP) por 30 segundos e vertido em pequenas porções até o total preenchimento do molde. Após 60 minutos os parafusos passantes dos transferentes foram desparafusados novamente e o conjunto molde/modelo foi separado, proporcionando à obtenção das réplicas do modelo mestre (Figura 15). Para cada variável analisada foi produzido 8 modelos. Os modelos obtidos foram armazenados à temperatura ambiente por no mínimo 120 horas até que as medidas sejam feitas.

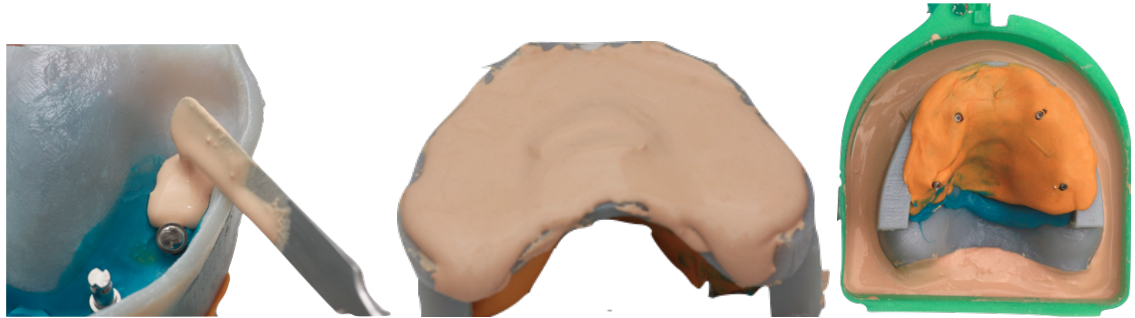
Figura 15 – Réplica do modelo mestre gesso pedra tipo IV



Fonte: Elaboração própria.

Foram utilizados dispositivos de plástico pré-fabricados para padronizar o formato e a quantidade de gesso dos modelos (Figura 16).

Figura 16 – Vazamento de com gesso tipo IV e utilização do dispositivo plástico para padronizar os modelos



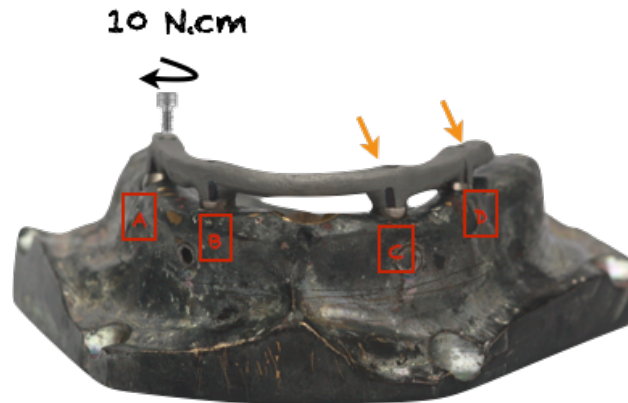
Fonte: Elaboração própria.

Registro dos desajustes verticais (adaptação cervical)

A estrutura metálica foi parafusada a cada modelo obtido, bem como no modelo mestre (grupo controle) com um parafuso de titânio manualmente até sentir leve torque no análogo A. Em seguida, foi dado um torque de 10 N.cm com torquímetro manual¹⁴ para manter a estrutura em uma posição constante enquanto as medições foram feitas nos análogos contralaterais (C e D). Posteriormente, o parafuso foi retirado do análogo

A e parafusado ao análogo D, enquanto o processo de leitura dos desajustes foi feito nos análogos A e B (Figura 17). Para cada grupo, um parafuso novo foi utilizado, evitando que o parafuso perca a rosca durante o aperto e afrouxamento do mesmo.

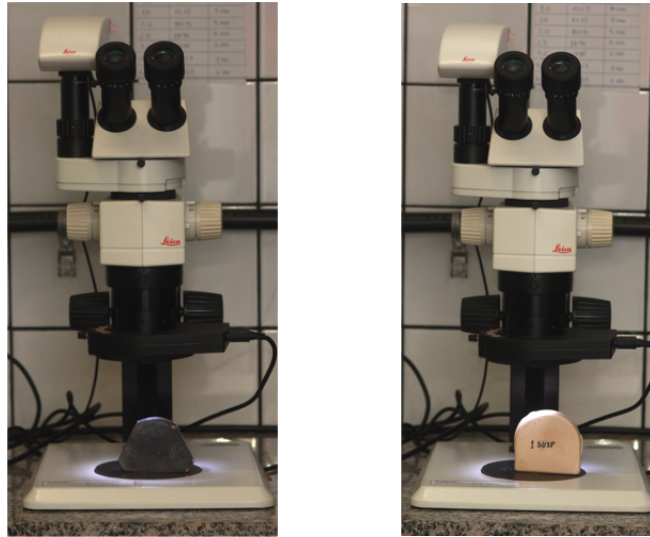
Figura 17 – Método de aferição das fendas



Fonte: Elaboração própria.

Foi padronizado o mesmo posicionamento (base posterior do modelo e da matriz apoiada na base da lupa) para realização das medidas, tanto no modelo mestre, como nos modelos de gesso. Garantido que todas as medidas fossem realizadas com a mesma intensidade de luz, com o mesmo ângulo de incidência e com a mesma distância do modelo para a lupa, isso com finalidade de que as medidas sejam obtidas da mesma forma (Figura 18).

Figura 18 – Posicionamento do modelo mestre e do modelo de gesso na lupa LEICA



Fonte: Elaboração própria.

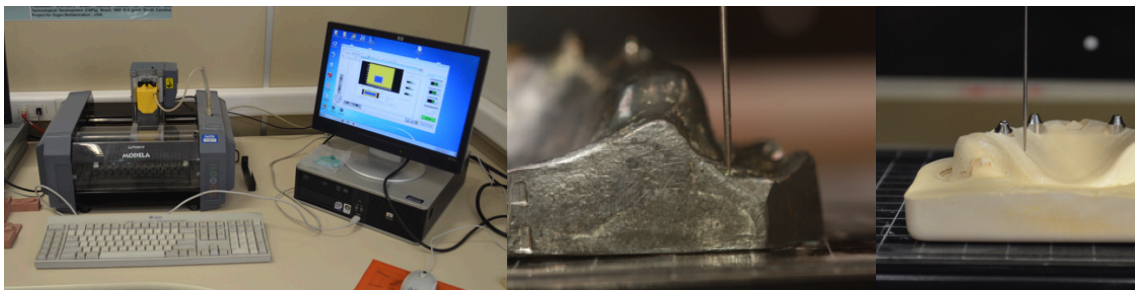
Foi utilizada uma lupa LEICA (fabricada em Cingapura) para ampliar (100X) e gravar a imagem da fenda formada entre a estrutura metálica e os análogos. As mensurações das fendas foram por meio do programa LEICA QWin (Leica Imaging Systems Ltd, Cambridge, England).

Para cada análogo foram realizadas três leituras, uma no centro e duas mais laterais, totalizando 12 leituras por corpo de prova.

Análise 3D da sobreposição de imagens digitais obtidas por escaneamento

Os modelos dos grupos experimentais obtidos por a partir das moldagens, assim como o modelos mestre foram escaneados pelo Scanner de contato (MDX-40, Roland, Centro de Tecnologia da Informação - CTI, Campinas, SP, Brasil) calibrado em 0,2mm para cada traçado da ponta de contato sobre a superfície escaneada (Figura 19).

Figura 19 – Escaneamento dos modelos pelo Scanner de contato



Fonte: Elaboração própria.

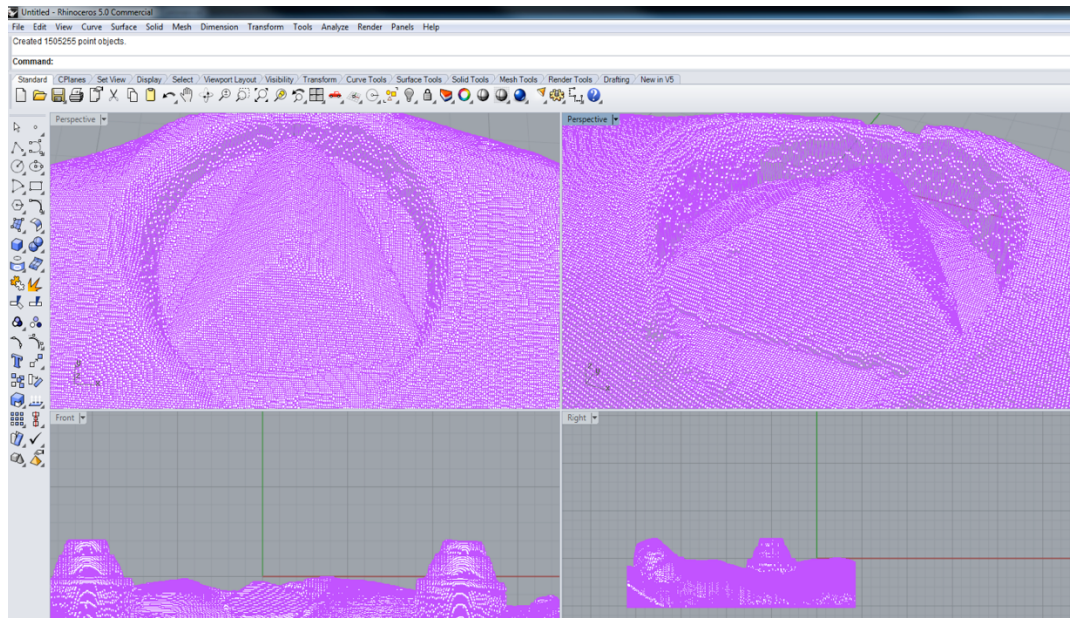
As imagens geradas em arquivos *.STL (Figura 20) a partir dos escaneamentos realizado pelo Scanner de contato e pela moldagem digital foram exportados para o programa Bio-CAD (Computer Assisted Desing; Rhino3D, Rhinoceros, USA) para análise e sobreposição das imagens para comparar o grau de fidelidade dos modelos em relação a matriz metálica (Figura 21).

Figura 20 – Arquivos *.STL do escaneamento



Fonte: Elaboração própria.

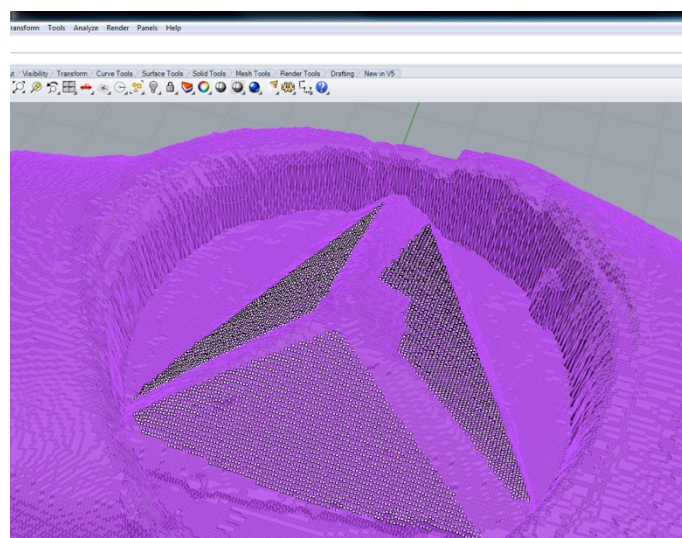
Figura 21 – Arquivos *.STL do escanamento exportado para o Bio-CAD



Fonte: Elaboração própria.

Essa sobreposição das imagens foi guiada pela pirâmide presente nos modelos. Inicialmente os pontos de cada face da pirâmide foram selecionados no programa Bio-CAD (Figura 22).

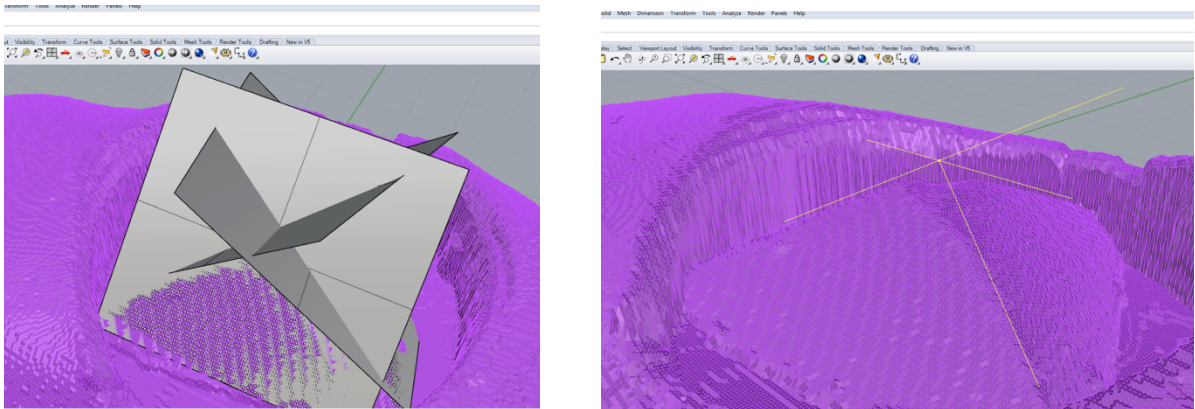
Figura 22 – Pontos selecionados de cada face da pirâmide no programa Bio-CAD



Fonte: Elaboração própria.

A partir dos pontos selecionados de cada face da pirâmide, planos foram projetados formando um ponto de intersecção e arestas entre eles (Figura 23).

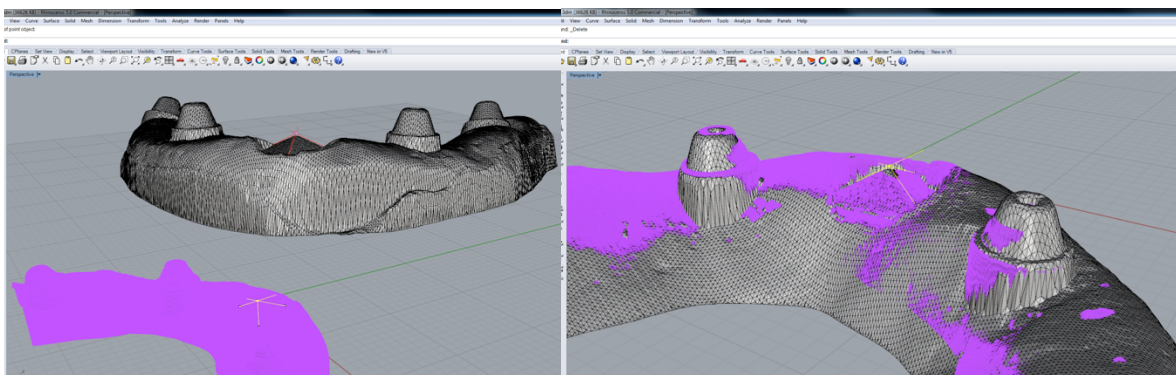
Figura 23 – Planos projetados de cada face da pirâmide formando um ponto de intersecção e arestas entre eles.



Fonte: Elaboração própria.

Com as arestas e ponto de intersecção definido, foi possível realizar a sobreposição dos arquivos dos modelos em relação ao modelo metálico, funcionando como referência para essa sobreposição (Figura 24).

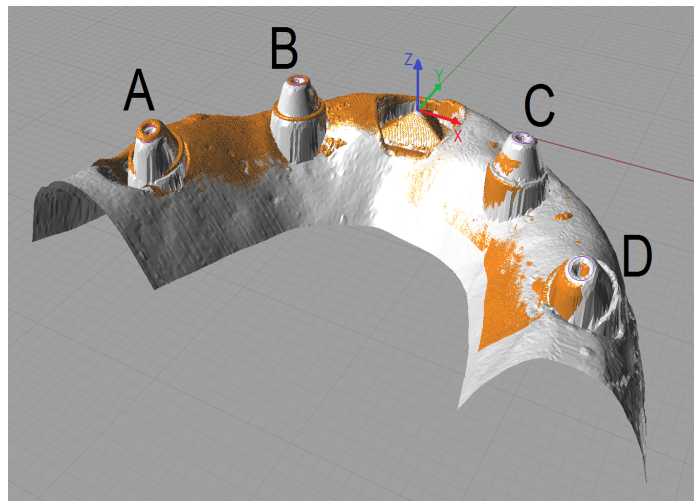
Figura 24 – Sobreposição da imagem do modelo com a imagem da matriz metálica guiado pelas arestas da pirâmide.



Fonte: Elaboração própria.

Dessa forma foi possível avaliar a diferença na posição dos análogos em 3D (nos eixos X,Y e Z) dos modelos dos grupos experimentais e do modelo mestre (Figura 25), sendo o ponto de intersecção entre os planos da pirâmide a posição absoluta 0 nos eixos X, Y e Z. Com isso foi possível calcular a posição absoluta dos análogos A, B, C e D em relação a posição do ponto de intersecção da pirâmide pelo progmrada Bio-CAD.

Figura 25 – Ilustração da sobreposição da imagem do modelo mestre com a imagem modelo do grupo experimental guiada pela pirâmide.



Fonte: Elaboração própria.

Os grupos amostrais (Quadro 1) do presente estudo foram os seguintes:

Quadro 1 – Grupos amostrais

Grupos	Tipo de Moldeira	Técnica de união dos transferentes
Grupo PC	Guia com palato	Sem União
Grupo PM	Guia com palato	Metal + Resina
Grupo PR	Guia com palato	Resina
Grupo OC	Guia sem palato	Sem União
Grupo OM	Guia sem palato	Metal + Resina
Grupo OR	Guia sem palato	Resina
Grupo GMM	Guia multifuncional	Metal + Resina
Grupo GMR	Guia multifuncional	Resina
Grupo MPM	Moldeira plástica	Metal + Resina
Grupo MPR	Moldeira plástica	Resina
Grupo MMM	Moldeira metálica	Metal + Resina
Grupo MMR	Moldeira metálica	Resina

Fonte: Elaboração própria.

Para cada grupo analisado foram produzidos 8 corpos de prova (tamanho amostral = n) a partir da literatura revisada.

APÊNDICE B - Dados gerais

Dados gerais publicação 1

Registro das Desadaptações (μm)

Modelo Mestre

	A	B	C	D
Modelo 1	136,08	131,38	224,76	141,15
Modelo 2	145,5	143,68	252,54	153,1
Modelo 3	131,38	131,38	236,34	142,24
Modelo 4	148,39	136,08	225,12	123,42
Modelo 5	148,03	132,1	222,95	139,34
Modelo 6	129,21	133,19	226,57	133,91
Modelo 7	148,39	142,96	259,5	134,27
Modelo 8	158,89	135,72	272,89	142,6

Grupo GMM

	A	B	C	D
Modelo 1	73,57	86,99	179,2	80,19
Modelo 2	131,39	170,7	145,52	90,48
Modelo 3	118,74	205,61	111,5	78,02
Modelo 4	141,91	125,98	206,31	82,18
Modelo 5	46,33	174,13	461,61	194,43
Modelo 6	56,19	74,97	502,8	318,54
Modelo 7	73,5	130,38	493	497,51
Modelo 8	123,3	106,2	176,35	340,23

Grupo MPM

	A	B	C	D
Modelo 1	258,45	221,51	220,23	135,04
Modelo 2	59,85	54,35	157,1	81,12
Modelo 3	52,18	62,28	163,26	87,26
Modelo 4	95,28	106,42	162,26	85,47
Modelo 5	95,2	125,96	124,21	99,63
Modelo 6	48,9	99,95	137,55	174,89
Modelo 7	144,84	91,61	188,94	325,02
Modelo 8	37,75	88,24	329,01	496,58

Grupo MMM

	A	B	C	D
Modelo 1	112,23	97,72	181,37	69,21
Modelo 2	158,56	206,32	197,18	97,38
Modelo 3	85,79	90,18	188,95	64,84
Modelo 4	73,54	93,43	230,2	90,48
Modelo 5	33,3	48,9	467,99	303,3
Modelo 6	53,23	111,87	368,11	351,82
Modelo 7	52,55	114,04	220,07	47,45
Modelo 8	64,06	127,79	346,39	469,82

Grupo GMR

	A	B	C	D
Modelo 1	40,22	81,84	149,84	26,78
Modelo 2	41,31	80,75	193,28	53,93
Modelo 3	45,64	250,83	203,06	51,03
Modelo 4	35,89	115,71	114,04	52,52
Modelo 5	50,31	143,38	86,91	45,61
Modelo 6	59,84	101,03	368,08	525,57
Modelo 7	74,68	131,39	72,77	74,94
Modelo 8	51,8	117,31	128,16	191,15

Grupo MPR

	A	B	C	D
Modelo 1	139	132,14	117,28	122,39
Modelo 2	52,63	97,81	149,94	66,26
Modelo 3	26,7	64,48	142,25	65,9
Modelo 4	172,74	130,86	138,66	65,17
Modelo 5	123,26	90,29	55,37	97,02
Modelo 6	58,8	224,89	99,93	62,64
Modelo 7	58,66	170,47	253,48	419,52
Modelo 8	158,58	209,63	191,13	341,36

Grupo MMR

	A	B	C	D
Modelo 1	85,79	109,33	157,46	66,62
Modelo 2	133,56	136,81	166,17	80,03
Modelo 3	47,81	69,52	318,14	224,4
Modelo 4	37,06	55,41	311,65	161,08
Modelo 5	43,15	48,54	289,19	333,56
Modelo 6	57,21	98,84	234,55	429,25
Modelo 7	50,71	147,32	39,49	117,64
Modelo 8	82,28	334,44	246,49	232,01

Registro da posição absoluta (mm) nos eixos X,Y e Z

Modelo Mestre

Eixos (x,y,z)	Implante A			Implante B			Implante C			Implante D		
	x	y	z	X	y	z	x	y	z	x	y	z
Matriz metálica	- 17,335	- 18,766	1,673	- 10,335	-5,054	1,965	11,765	-5,066	1,860	20,294	- 18,280	0,879

Grupo GMM

Eixos (x,y,z)	Análogo A			Análogo B			Análogo C			Análogo D		
	x	y	z	X	y	z	x	y	z	x	y	z
Modelo 1	- 17,456	- 18,686	1,589	- 10,332	-4,991	2,107	11,718	-5,180	1,784	20,217	- 18,458	0,548
Modelo 2	- 17,547	- 18,630	1,399	- 10,457	-4,993	1,996	11,677	-5,168	1,980	20,195	- 18,530	1,107
Modelo 3	- 17,544	- 18,676	1,323	- 10,417	-4,958	2,033	11,773	-5,206	1,978	20,2	- 18,600	0,876
Modelo 4	- 17,463	- 18,815	1,588	- 10,437	-4,958	2,059	11,763	-5,101	2,004	20,347	- 18,415	0,989
Modelo 5	- 17,604	- 18,649	1,445	- 10,418	-4,956	2,003	11,691	-5,175	2,120	20,182	- 18,638	1,304
Modelo 6	- 17,498	- 18,697	1,566	- 10,340	-4,987	2,063	11,757	-5,168	1,906	20,233	- 18,469	0,815
Modelo 7	- 17,533	- 18,661	1,329	- 10,455	-5,015	2,003	11,713	-5,280	1,939	20,140	- 18,656	0,779
Modelo 8	- 17,653	- 18,661	1,561	- 10,434	-4,989	2,081	11,778	-5,214	1,931	20,260	- 18,475	1,004

Grupo MPM

Eixos (x,y,z)	Análogo A			Análogo B			Análogo C			Análogo D		
	x	y	z	X	y	z	x	y	z	x	y	z
Modelo 1	- 17.506	- 18.702	1.669	- 10.408	-4.915	2.050	11.798	-5.072	2.160	20.194	- 18.555	1.347
Modelo 2	- 17.420	- 18.770	1.544	- 10.326	-5.005	2.114	11.740	-5.109	1.981	20.326	- 18.444	0.961
Modelo 3	- 17.669	- 18.601	1.377	- 10.489	-4.944	2.030	11.666	-5.274	2.009	20.125	- 18.678	0.904
Modelo 4	- 17.324	- 18.772	1.760	- 10.331	-5.031	2.148	11.786	-5.059	1.845	20.393	- 18.413	0.754
Modelo 5	- 17.386	- 18.782	1.604	- 10.319	-5.056	2.110	11.771	-5.161	1.987	20.287	- 18.467	1.046
Modelo 6	- 17.502	- 18.670	1.620	- 10.440	-4.948	2.078	11.693	-5.226	1.956	20.215	- 18.608	1.013
Modelo 7	- 17.556	- 18.685	1.660	- 10.372	-4.959	2.075	11.649	-5.286	1.847	20.192	- 18.580	0.890
Modelo 8	- 17.423	- 18.676	1.676	- 10.405	-5.031	2.079	11.736	-5.117	2.091	20.370	- 18.365	1.362

Grupo MMM

Eixos (x,y,z)	Análogo A			Análogo B			Análogo C			Análogo D		
	x	y	z	X	y	z	x	y	z	x	y	z
Modelo 1	- 17.633	- 18.617	1.485	- 10.410	-4.973	2.055	11.661	-5.262	2.064	20.135	- 18.559	1.160
Modelo 2	- 17.346	- 18.748	1.453	- 10.379	-5.021	2.034	11.719	-5.136	2.008	20.331	- 18.411	0.980
Modelo 3	- 17.379	- 18.833	1.455	- 10.360	-5.049	2.016	11.797	-5.071	2.026	20.284	- 18.388	1.008
Modelo 4	- 17.395	- 18.793	1.563	- 10.289	-5.031	2.108	11.775	-5.123	1.974	20.344	- 18.395	0.951
Modelo 5	- 17.699	- 18.497	1.555	- 10.442	-4.865	2.031	11.670	-5.309	2.064	20.082	- 18.731	1.167
Modelo 6	- 17.473	- 18.664	1.538	- 10.383	-5.022	2.056	11.619	-5.154	2.054	20.190	- 18.563	1.121
Modelo 7	- 17.414	- 18.753	1.535	- 10.372	-4.995	2.005	11.740	-5.159	2.093	20.289	- 18.488	1.182
Modelo 8	- 17.443	- 18.679	1.849	- 10.394	-4.977	2.189	11.799	-5.137	2.056	20.330	- 18.398	1.267

Grupo GMR

Eixos (x,y,z)	Análogo A			Análogo B			Análogo C			Análogo D		
	x	y	z	X	y	z	x	y	z	x	y	z
Modelo 1	-	-	1.485	-	-5.012	2.003	11.724	-5.154	2.158	20.210	-	1.333
Modelo 2	17.545	18.630	1.190	10.390	-4.938	1.885	11.576	-5.331	2.151	20.064	18.646	1.284
Modelo 3	-	-	1.514	-	-4.943	2.075	11.788	-5.229	2.145	20.176	-	1.221
Modelo 4	17.553	18.649	1.403	10.400	-4.945	1.991	11.691	-5.238	2.114	20.138	18.574	1.228
Modelo 5	-	-	1.422	-	-4.948	1.987	11.721	-5.147	2.048	20.296	-	1.255
Modelo 6	17.480	18.721	1.371	10.412	-4.976	1.958	11.663	-5.192	2.165	20.203	18.517	1.358
Modelo 7	-	-	1.492	-	-5.059	2.019	11.630	-5.048	2.128	20.290	-	1.385
Modelo 8	17.539	18.733	1.528	10.371	-4.952	2.009	11.600	-5.071	2.054	20.329	18.429	1.108

Grupo MPR

Eixos (x,y,z)	Análogo A			Análogo B			Análogo C			Análogo D		
	x	y	z	X	y	z	x	y	z	x	y	z
Modelo 1	-	-	1.667	-	-4.942	2.054	11.666	-5.219	2.061	20.280	-	1.244
Modelo 2	17.504	18.699	1.423	10.393	-4.931	2.039	11.698	-5.201	2.073	20.147	18.486	1.207
Modelo 3	-	-	1.561	-	-5.059	2.072	11.716	-5.109	2.147	20.423	-	1.337
Modelo 4	17.643	18.514	1.409	10.387	-4.976	1.970	11.579	-5.316	2.104	20.159	18.585	1.260
Modelo 5	-	-	1.615	-	-4.936	2.089	11.717	-5.206	1.920	20.135	-	0.804
Modelo 6	17.500	18.607	1.669	10.393	-4.935	2.223	11.702	-5.192	1.919	20.178	18.634	0.791
Modelo 7	-	-	1.400	-	-4.959	2.029	11.759	-5.199	2.040	20.232	-	1.099
Modelo 8	17.451	18.647	1.776	10.343	-5.123	2.175	11.828	-5.045	2.048	20.232	18.594	1.233

Grupo MMR

Eixos (x,y,z)	Análogo A			Análogo B			Análogo C			Análogo D		
	x	y	z	X	y	z	x	y	z	x	y	z
Modelo 1	- 17.473	- 18.743	1.468	- 10.386	-5.022	2.001	11.762	-5.133	2.056	20.312	- 18.452	1.041
Modelo 2	- 17.462	- 18.723	1.345	- 10.442	-5.081	2.022	11.745	-5.169	2.125	20.264	- 18.507	1.204
Modelo 3	- 17.521	- 18.703	1.453	- 10.381	-4.970	1.978	11.715	-5.125	2.198	20.278	- 18.449	1.377
Modelo 4	- 17.643	- 18.589	1.415	- 10.481	-4.935	2.033	11.584	-5.192	2.091	20.068	- 18.595	1.225
Modelo 5	- 17.550	- 18.712	1.497	- 10.415	-4.983	2.005	11.674	-5.184	2.067	20.211	- 18.516	1.177
Modelo 6	- 17.829	- 18.405	1.594	- 10.573	-4.812	2.128	11.663	-5.306	1.991	20.022	- 18.776	1.168
Modelo 7	- 17.510	- 18.641	1.761	- 10.405	-4.992	2.056	11.691	-5.121	2.195	20.488	- 18.317	1.675
Modelo 8	- 17.442	- 18.696	1.565	- 10.445	-5.005	2.073	11.838	-5.168	1.801	20.358	- 18.498	0.927

Dados gerais publicação 2

Registro das Desadaptações (μm)

Modelo Mestre

	A	B	C	D
Modelo 1	136,08	131,38	224,76	141,15
Modelo 2	145,5	143,68	252,54	153,1
Modelo 3	131,38	131,38	236,34	142,24
Modelo 4	148,39	136,08	225,12	123,42
Modelo 5	148,03	132,1	222,95	139,34
Modelo 6	129,21	133,19	226,57	133,91
Modelo 7	148,39	142,96	259,5	134,27
Modelo 8	158,89	135,72	272,89	142,6

Grupo OC

	A	B	C	D
Modelo 1	111,84	175,17	202,32	144,77
Modelo 2	149,12	182,41	197,97	169,74
Modelo 3	199,78	268,19	214,29	130,29
Modelo 4	146,58	128,12	123,05	110,03
Modelo 5	161,78	215,35	185,3	111,11
Modelo 6	233,44	184,96	153,46	163,23
Modelo 7	200,87	55,74	149,84	100,98
Modelo 8	100,61	200,51	293,52	159,97

Grupo PC

	A	B	C	D
Modelo 1	144,77	68,04	205,94	81,43
Modelo 2	176,62	234,17	183,86	109,3
Modelo 3	130,3	289,18	235,98	110,39
Modelo 4	134,27	255,88	265,29	126,31
Modelo 5	214,26	216,07	218,24	126,31
Modelo 6	274,7	278,68	242,85	178,79
Modelo 7	176,62	233,8	218,24	178,79
Modelo 8	136,08	269,27	241,04	197,97

Grupo OM

	A	B	C	D
Modelo 1	194,72	145,85	206,30	144,05
Modelo 2	165,40	113,65	195,80	110,03
Modelo 3	116,90	92,65	224,75	109,67
Modelo 4	161,06	141,15	241,40	116,54
Modelo 5	236,34	159,97	195,44	171,55
Modelo 6	158,33	149,39	238,51	141,87
Modelo 7	275,43	205,21	245,38	191,46
Modelo 8	123,05	114,73	264,57	180,24

Grupo PM

	A	B	C	D
Modelo 1	152,29	150,92	193,63	96,63
Modelo 2	209,92	181,32	195,80	149,12
Modelo 3	168,66	138,25	124,86	64,43
Modelo 4	169,38	123,42	194,72	110,03
Modelo 5	204,85	128,84	275,43	187,84
Modelo 6	79,26	45,24	131,74	99,53
Modelo 7	178,79	114,73	227,29	165,76
Modelo 8	100,62	93,37	244,30	158,05

Grupo OR

	A	B	C	D
Modelo 1	240,32	189,65	234,53	166,04
Modelo 2	256,97	207,75	220,77	220,77
Modelo 3	166,12	144,05	225,48	161,06
Modelo 4	213,53	146,58	211	147,3
Modelo 5	210,28	150,2	211,73	165,76
Modelo 6	204,85	149,11	223,31	157,8
Modelo 7	211,36	198,7	275,79	201,23
Modelo 8	218,6	157,07	229,82	179,52

Grupo PR

	A	B	C	D
Modelo 1	207,38	155,27	239,96	182,77
Modelo 2	203,04	178,43	259,14	174,45
Modelo 3	238,38	213,9	200,87	138,98
Modelo 4	203,76	230,91	191,1	106,41
Modelo 5	205,57	153,1	148,03	135,36
Modelo 6	203,04	171,92	273,04	192,91
Modelo 7	206,3	169,02	235,98	171,36
Modelo 8	195,44	156,3	205,57	169,38

Registro da posição absoluta (mm) nos eixos X,Y e Z

Modelo Mestre

Eixos (x,y,z)	Implante A			Implante B			Implante C			Implante D		
	x	y	z	X	y	z	x	y	z	x	y	z
Matriz metálica	-17,335	-18,766	1,673	-10,335	-5,054	1,965	11,765	-5,066	1,860	20,294	-18,280	0,879

Grupo PC

Eixos (x,y,z)	Análogo A			Análogo B			Análogo C			Análogo D		
	x	y	z	X	y	z	x	y	z	x	y	z
Modelo 1	-17,446	-18,780	1,736	-10,311	-4,988	2,001	11,771	-5,080	1,929	20,344	-18,347	0,903
Modelo 2	-17,480	-18,890	1,636	-10,363	-5,054	2,164	11,772	-5,071	1,877	20,402	-18,470	0,930
Modelo 3	-17,474	-18,839	1,598	-10,375	-5,049	2,111	11,762	-5,091	1,878	20,351	-18,442	0,869
Modelo 4	-17,441	-18,869	1,662	-10,375	-5,038	2,112	11,782	-5,048	1,973	20,356	-18,425	0,961
Modelo 5	-17,358	-18,873	1,687	-10,340	-5,035	2,113	11,801	-5,012	2,006	20,438	-18,353	1,055
Modelo 6	-17,521	-18,770	1,657	-10,412	-4,994	2,147	11,729	-5,111	1,898	20,281	-18,460	0,742
Modelo 7	-17,470	-18,821	1,778	-10,343	-5,031	2,171	11,794	-5,109	1,936	20,342	-18,440	0,994
Modelo 8	-17,369	-18,889	1,669	-10,332	-5,032	2,106	11,792	-5,029	2,008	20,410	-18,350	1,048

Grupo PM

Eixos (x,y,z)	Análogo A			Análogo B			Análogo C			Análogo D		
	x	y	z	X	y	z	x	y	z	x	y	z
Modelo 1	- 17,343	- 18,854	1,694	- 10,329	-5,063	2,212	11,788	-5,082	1,983	20,326	- 18,386	0,918
Modelo 2	- 17,413	- 18,812	1,803	- 10,365	-4,980	2,151	11,785	-5,096	1,996	20,321	- 18,403	1,083
Modelo 3	- 17,353	- 18,776	1,688	- 10,381	-5,034	2,127	11,789	-5,054	1,953	20,337	- 18,340	0,972
Modelo 4	- 17,389	- 18,848	1,699	- 10,339	-5,039	2,189	11,772	-5,130	1,915	20,365	- 18,373	0,859
Modelo 5	- 17,398	- 18,834	1,619	- 10,351	-5,080	2,138	11,814	-5,050	2,035	20,393	- 18,351	1,007
Modelo 6	- 17,398	- 18,840	1,571	- 10,418	-5,098	2,093	11,754	-5,071	1,939	20,376	- 18,396	0,904
Modelo 7	- 17,405	- 18,823	1,573	- 10,398	-5,090	2,149	11,764	-5,085	1,912	20,396	- 18,433	0,893
Modelo 8	- 17,510	- 18,846	1,629	- 10,385	-5,090	2,173	11,775	-5,153	1,947	20,303	- 18,419	0,872

Grupo PR

Eixos (x,y,z)	Análogo A			Análogo B			Análogo C			Análogo D		
	x	y	z	X	y	z	x	y	z	x	y	z
Modelo 1	- 17,387	- 18,810	1,804	- 10,350	-5,040	2,159	11,723	-5,083	2,000	20,366	- 18,335	1,104
Modelo 2	- 17,325	- 18,899	1,622	- 10,318	-5,081	2,103	11,766	-5,026	1,985	20,418	- 18,233	0,966
Modelo 3	- 17,448	- 18,770	1,532	- 10,376	-5,104	2,107	11,734	-5,145	1,866	20,355	- 18,394	0,789
Modelo 4	- 17,369	- 18,746	1,729	- 10,410	-4,996	2,127	11,768	-4,997	2,082	20,435	- 18,277	1,185
Modelo 5	- 17,362	- 18,801	1,582	- 10,429	-5,135	2,054	11,755	-5,047	2,097	20,366	- 18,322	1,181
Modelo 6	- 17,306	- 18,834	1,733	- 10,290	-5,029	2,121	11,839	-4,952	2,049	20,565	- 18,217	1,081
Modelo 7	- 17,219	- 18,951	1,643	- 10,334	-5,113	2,092	11,716	-4,953	2,086	20,547	- 18,125	1,103
Modelo 8	- 17,251	- 18,907	1,761	- 10,310	-5,138	2,167	11,812	-5,031	2,007	20,540	- 18,250	0,878

Grupo OC

Eixos (x,y,z)	Análogo A			Análogo B			Análogo C			Análogo D		
	x	y	z	X	y	z	x	y	z	x	y	z
Modelo 1	- 17,195	- 18,497	1,816	- 10,470	-4,783	2,174	11,676	-5,369	1,932	20,026	- 18,815	1,089
Modelo 2	- 17,425	- 18,854	1,670	- 10,342	-5,045	2,159	11,771	-5,048	1,899	20,420	- 18,341	0,973
Modelo 3	- 17,466	- 18,813	1,723	- 10,405	-5,037	2,062	11,768	-5,076	1,937	20,309	- 18,443	0,898
Modelo 4	- 17,473	- 18,810	1,585	- 10,395	-5,064	2,150	11,768	-5,127	1,913	20,380	- 18,410	0,932
Modelo 5	- 17,529	- 18,826	1,633	- 10,380	-5,035	2,041	11,795	-5,126	1,887	20,344	- 18,429	0,931
Modelo 6	- 17,502	- 18,820	1,642	- 10,419	-5,001	2,013	11,761	-5,100	1,944	20,311	- 18,416	0,943
Modelo 7	- 17,468	- 18,777	1,751	- 10,389	-5,041	2,172	11,796	-5,125	1,906	20,302	- 18,440	0,907
Modelo 8	- 17,483	- 18,803	1,726	- 10,426	-4,973	2,068	11,780	-5,129	1,979	20,316	- 18,427	1,048

Grupo OM

Eixos (x,y,z)	Análogo A			Análogo B			Análogo C			Análogo D		
	x	y	z	X	y	z	x	y	z	x	y	z
Modelo 1	- 17,145	- 19,093	1,139	- 10,362	-5,228	1,895	11,809	-4,924	2,086	20,589	- 18,077	1,238
Modelo 2	- 17,234	- 19,006	1,554	- 10,301	-5,191	1,981	11,811	-4,98	2,062	20,538	- 18,051	1,212
Modelo 3	- 17,162	- 19,084	1,403	- 10,312	-5,225	1,907	11,822	-4,912	2,145	20,651	- 17,970	1,290
Modelo 4	- 17,242	- 18,912	1,552	- 10,365	-5,130	2,075	11,786	-4,900	2,108	20,502	- 18,095	1,197
Modelo 5	- 17,283	- 18,902	1,598	- 10,360	-5,118	2,062	11,761	-4,971	2,004	20,489	- 18,130	1,071
Modelo 6	- 17,482	- 18,826	1,786	- 10,342	-5,053	2,180	11,774	-5,081	1,965	20,332	- 18,398	0,976
Modelo 7	- 17,545	- 18,646	1,766	- 10,434	-4,988	2,158	11,697	-5,192	1,886	20,193	- 18,534	0,892
Modelo 8	- 17,521	- 18,710	1,709	- 10,347	-5,030	2,195	11,750	-5,181	1,877	20,227	- 18,470	0,810

Grupo OR

Eixos (x,y,z)	Análogo A			Análogo B			Análogo C			Análogo D		
	x	y	z	X	y	z	x	y	z	x	y	z
Modelo 1	- 17.292	- 18.868	1.766	- 10.340	-5.119	2.125	11.812	-5.030	2.011	20.556	- 18.201	1.101
Modelo 2	- 17.317	- 18.874	1.682	- 10.301	-5.106	2.073	11.777	-4.956	2.086	20.586	- 18.123	1.200
Modelo 3	- 17.496	- 18.773	1.711	- 10.376	-5.023	2.128	11.807	-5.120	1.977	20.345	- 18.441	0.981
Modelo 4	- 17.295	- 18.853	1.724	- 10.525	-5.077	2.153	11.789	-4.973	2.082	20.477	- 18.271	1.278
Modelo 5	- 17.412	- 18.786	1.541	- 10.415	-5.130	2.105	11.735	-5.083	1.990	20.357	- 18.360	0.959
Modelo 6	- 17.520	- 18.647	1.597	- 10.399	-4.990	2.089	11.734	-5.124	1.998	20.249	- 18.505	0.992
Modelo 7	- 17.432	- 18.667	2.009	- 10.272	-5.001	2.233	11.771	-5.059	1.934	20.335	- 18.316	1.106
Modelo 8	- 17.259	- 18.847	1.610	- 10.314	-5.118	2.179	11.864	-5.020	1.922	20.510	- 18.253	0.811

ANEXO A - Comprovante status Artigo 1 e Artigo 2

Clinical Oral Investigations

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