UNIVERSIDADE FEDERAL FLUMINENSE
FACULDADE DE ODONTOLOGIA

AVALIAÇÃO DA ACURÁCIA E CONFIABILIDADE DE MODELOS DENTÁRIOS DIGITAIS OBTIDOS POR DIFERENTES MÉTODOS DE AQUISIÇÃO

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Tese apresentada à Faculdade de Odontologia da Universidade Federal Fluminense, como parte dos requisitos para obtenção do título de Doutor, pelo Programa de Pós-Graduação em Odontologia.

Área de Concentração: Clínica Odontológica

Orientadores: Prof. Dr. Oswaldo de Vasconcellos Vilella e Prof. Dr. Karel Hero Breuning

Niterói
2015

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Winston Churchill

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RESUMO

Camardella LT. Avaliação da acurácia e confiabilidade de modelos dentários digitais obtidos por diferentes métodos de aquisição [Tese de Doutorado]. Niterói: Universidade Federal Fluminense, Faculdade de Odontologia; 2015.

O objetivo deste estudo foi avaliar a acurácia e a confiabilidade de medições em modelos digitais obtidos por quatro diferentes métodos: 1) escaneamento de modelos de gesso por scanner a laser, 2) escaneamento de modelos de gesso por scanner por tomografia computadorizada, 3) escaneamento a laser de moldagens em silicone de adição, e 4) escaneamento intrabucal. Modelos de gesso de 30 voluntários foram utilizados como padrão ouro para comparação com os modelos digitais. Quatro examinadores mediram os modelos de gesso com um paquímetro digital e os modelos digitais com o programa Ortho Analyzer (3Shape, Copenhagen, Dinamarca), sendo que os modelos digitais pelos dois métodos de escaneamento do modelo de gesso também foram medidos pelo programa Digimodel (OrthoProof, Niewegein, Holanda) por apenas dois examinadores. As moldagens em silicone de adição dos voluntários foram escaneadas e divididas de acordo com o tipo de base leve utilizada (regular para o arco superior e leve para o arco inferior) e de acordo com o período pós-moldagem em 5, 10 e 15 dias. O erro intra-examinador e a comparação entre os modelos de gesso e os digitais foram obtidos pelo teste *t* pareado. A confiabilidade intra-examinador foi obtida pelo coeficiente de correlação intraclasse e pelo coeficiente de correlação de Person. Embora tenham sido encontradas diferenças estatisticamente significantes entre as medições em modelos de gesso e modelos digitais, estas discrepâncias não foram clinicamente significantes, exceto para o overbite nos modelos digitais por escanemento de moldagens em silicone de adição. Os modelos digitais a partir do escaneamento do modelo de gesso pelo scanner a laser ou por tomografia computadorizada apresentaram acurácia e confiabilidade clinicamente aceitáveis independentemente do programa utilizado, e podem substituir os modelos de gesso convencionais. Os modelos digitais adquiridos por escaneamento intrabucal e por escaneamento a laser de moldagens em silicone de adição, com os dois tipos de base leve estudados, podem ser utilizados com acurácia e confiabilidade clinicamente aceitáveis, mesmo em um intervalo pós-moldagem de até 15 dias.

Palavras-chave: modelos digitais, scanners, ortodontia.

ABSTRACT

Camardella LT. Evaluation of the accuracy and reliability of digital dental models acquired by different acquisition methods [Phd Thesis]. Niterói: Universidade Federal Fluminense, Faculdade de Odontologia; 2015.

The objective of this study was to evaluate the accuracy and the reliability of measurements on digital models obtained by four different methods: 1) plaster models scanning by laser scanner, 2) plaster models scanning by computerized tomography scanner, 3) laser scanning of PVS impressions, and 4) intraoral scanning. Plaster models of 30 volunteers were used as gold standard for comparison with digital models. Four examiners measured the plaster models with a digital caliper and the digital models with Ortho Analyzer software (3Shape, Copenhagen, Denmark), and the digital models for both plaster model scanning methods were also measured by Digimodel software (OrthoProof, Niewegein, Netherlands) by only two examiners. The PVS impressions of the volunteers were scanned and divided in accordance with the type of light base material used (regular for the upper arch and light for the lower arch) and in accordance with the post-impression taking period in 5, 10 and 15 days. The intra-examiner error and the comparison between the plaster and digital models were obtained by paired *t* test. The intra-examiner reliability was obtained by the intraclass correlation coefficient and the Pearson correlation coefficient. Although statistically significant differences were found between measurements on plaster models and digital models, these differences were not considered clinically significant, except for the overbite in digital models for PVS impression scanning. The digital models made from plaster model scanning by laser or computerized tomography scanner showed a clinically acceptable accuracy and reliability, independently of the software used, and they can replace the conventional plaster models. The digital models acquired by intraoral scan and PVS impressions laser scanning, with the two types of light base studied can be used with a clinically acceptable accuracy and reliability, even in a post-impression taking interval of up to 15 days.

Keywords: digital models, scanners, orthodontics.

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1 - INTRODUÇÃO

Uma documentação ortodôntica detalhada é imprescindível para o ortodontista obter as informações necessárias que possibilitem um correto diagnóstico e planejamento ortodôntico. Um bom padrão de documentação envolve basicamente: fichas de consulta, fotografias intrabucais e extrabucais; um conjunto de radiografias que pode constar de panorâmica, interproximais, periapicais e telerradiografia de acordo com o caso e a idade do paciente; e os modelos confeccionados em gesso (Camargo e Mucha, 1999).

Os modelos, assim como cada elemento da documentação ortodôntica, perpetuam, ao longo do tempo, as condições morfológicas do sistema estomatognático captadas em um determinado momento. Isto possibilita, além do diagnóstico e do plano de tratamento inicial, infinitas comparações, estabelecendo uma análise dinâmica da evolução dos casos clínicos. Os modelos de gesso asseguram um registro permanente da má oclusão em três dimensões, logo permite observar detalhes importantes que muitas vezes são difíceis de serem visualizados na boca, analisar a simetria e forma dos arcos, inclinação, anatomia, tamanho e posição dos dentes, bem como aplicar diferentes análises ortodônticas. Além disso, constituem-se em valiosa forma de registro legal, sendo de grande utilidade na comparação das diferentes fases do tratamento e transferência de pacientes entre profissionais (Habib et al., 2007).

A prática ortodôntica vem cada vez mais incorporando a tecnologia da informática em seu dia a dia. A tendência é de se obter um consultório sem papel, incluindo os prontuários e registros. As radiografias e fotografias digitais estão substituindo os métodos tradicionais, e a tomografia computadorizada por feixe cônico (TCFC) está sendo bem mais empregada no consultório. A possibilidade de obtenção do modelo digital por escaneamento do modelo de gesso ou pelo escaneamento intrabucal, fornece diversas vantagens ao profissional, além de ser o próximo passo na evolução da documentação ortodôntica (Polido, 2010).

As principais vantagens do modelo digital são: precisão e rapidez na obtenção de dados para o diagnóstico; facilidade de armazenamento (Stevens et al., 2006; Mullen et al., 2007; Sousa et al., 2012; Wiranto et al., 2013); possibilidade de transferência de informações através dos meios de comunicação virtual (Stevens et al., 2006; Sousa et al., 2012; Wiranto et al., 2013); maior facilidade de realização de análises ortodônticas e confecção de *set ups* virtuais.

Algumas desvantagens do uso de modelos digitais para os ortodontistas seriam o maior custo de confecção, falta de familiarização na análise de modelos ortodônticos digitais (Asquith et al., 2007; El-Zanaty et al., 2010; Shastry e Park, 2014) e impossibilidade de tato (Shastry e Park, 2014).

No ano de 2014, 35% dos programas de pós-graduação em ortodontia dos Estados Unidos e Canadá utilizavam modelos de estudo digitais na maioria dos casos tratados, com tendência de aumento em sua utilização no futuro (Shastry e Park, 2014), principalmente com a popularização dos alinhadores estéticos por CAD/CAM (Kuo e Miller, 2003) e o desenvolvimento de outros recursos, como a customização de braquetes para o tratamento ortodôntico (Grauer e Proffit, 2011) e o planejamento orto-cirúrgico virtual com a confecção de guias cirúrgicas digitais por prototipagem (Hernandez-Alfaro e Guijarro-Martinez, 2013).

O modelo digital pode ser adquirido por diversas maneiras, didaticamente divididas em dois métodos: indireto e direto (Cuperus et al., 2012). O método indireto pode ser realizado pelo escaneamento de modelos de gesso e moldagens, enquanto que, pelo método direto, o modelo digital pode ser adquirido pelo escaneamento intrabucal ou pela TCFC do paciente. A utilização da TCFC com o único propósito de obtenção de modelos digitais nunca deve ser a primeira opção do profissional em virtude de incidir radiação ionizante ao paciente, além destes modelos apresentarem menor acurácia em relação aos outros métodos de aquisição (Akyalcin et al., 2013; de Waard et al., 2014).

Diversos estudos verificaram a acurácia e a confiabilidade de modelos digitais a partir de variados métodos de aquisição, como o escaneamento a laser de modelos de gesso (Stevens et al., 2006; Mullen et al., 2007; Bootvong et al., 2010; Abizadeh et al., 2012; Sousa et al., 2012; Kim et al., 2014), escaneamento a laser de moldagens (Zilberman et al., 2003; Bootvong et al., 2010; Kau et al., 2010), escaneamento de moldagens com scanners por tomografia computadorizada (Torassian et al., 2010; White et al., 2010; Wiranto et al., 2013), por escaneamento intrabucal (Cuperus et al., 2012; Flugge et al., 2013; Naidu e Freer, 2013; Wiranto et al., 2013), e pela TCFC do paciente (Creed et al., 2011; de Waard et al., 2014; Grunheid et al., 2014; Kim et al., 2014). A grande maioria dos trabalhos não identificou diferenças clinicamente significantes nas medidas dos modelos digitais, com exceção de poucos estudos (Torassian et al., 2010; White et al., 2010).

Dentre os estudos avaliados, foram comparados diferentes métodos de aquisição de modelos digitais com amostras diferentes, diversas medidas foram realizadas utilizando diferentes programas, além de serem realizadas comparações por medição entre os modelos de gesso e os modelos digitais e superposição entre os modelos digitais. Estas variáveis podem limitar ou mesmo prejudicar a interpretação dos resultados. Além disso, embora a acurácia e confiabilidade de modelos digitais por escaneamento de modelos e moldagens tenha sido mais estudada na literatura, existe uma carência de pesquisas avaliando a acurácia e confiabilidade de modelos digitais por escaneamento intrabucal em condições clínicas, sendo que o scanner Trios Color (3Shape®, Copenhagen, Dinamarca) ainda não foi estudado (Goracci et al., 2015).

Em virtude das diversas vantagens atribuídas aos modelos digitais e sua possível substituição ao modelo de gesso como ferramenta de diagnóstico em médio prazo, este estudo objetiva avaliar a acurácia e confiabilidade de modelos digitais obtidos por diferentes métodos de aquisição a partir de uma mesma amostra. Para isso, selecionou-se uma amostra contendo 30 voluntários e a partir dela os modelos digitais foram gerados pelos seguintes métodos: escaneamento do modelo de gesso (a laser e por tomografia computadorizada), escaneamento a laser de moldagens em silicone de adição e escaneamento intrabucal. Os modelos de gesso, considerados como padrão ouro, foram medidos com auxílio de um paquímetro digital e os modelos digitais foram medidos em programas de manipulação de modelos virtuais. Os resultados de ambas medições foram comparados por meio de testes estatísticos para avaliar se os modelos digitais adquiridos pelos variados métodos descritos possuem acurácia e confiabilidade satisfatórias para serem utilizados em rotina na clínica ortodôntica, podendo assim substituir os modelos de gesso.

2 - METODOLOGIA

2.1 - Material

Realizou-se um cálculo amostral utilizando a fórmula descrita por Pandis (Pandis, 2012), considerando um poder de teste de 90%, α de 0,05, diferença a ser detectada de 1 mm, e um desvio padrão de 1,16 mm, por meio de um estudo piloto prévio com 10 indivíduos. O cálculo amostral revelou a necessidade de uma amostra composta por 29 indivíduos, portanto selecionou-se um total de 30 voluntários para a pesquisa.

Foram selecionados 30 indivíduos na Disciplina de Ortodontia da Universidade Federal Fluminense (21 do sexo feminino e 9 do sexo masculino). Os voluntários possuíam idades entre 21 e 39 anos, com média de 27 anos e 9 meses. Todos foram informados sobre a pesquisa e assinaram o termo de consentimento livre e esclarecido. O trabalho foi aprovado por um comitê de ética local sob o número 221.664 no dia 01 de fevereiro de 2013 (Anexo B).

Os critérios de inclusão da amostra foram os seguintes:

- Presença de dentição permanente com todos os dentes totalmente irrompidos (no mínimo de 1º molar a 1º molar permanente superior e inferior),
- Ausência de anomalias de número, tamanho e forma,
- Presença de dentes sem recessões, abrasões, atrições e erosões acentuadas,
- Presença de dentes sem cáries ou restaurações que comprometessem o diâmetro mesiodistal de suas coroas dentárias,
- Ausência de contenção ortodôntica fixa.

Em cada voluntário foi realizado um exame clínico, fotografias intra e extrabucais, moldagem em alginato para confecção de modelo de estudo em gesso que foi vazado em até 1 hora pós-moldagem, moldagem em silicone de adição para envio para digitalização e escaneamento intrabucal da oclusão.

2.1.1 – Confecção dos modelos de gesso e escaneamento

Para a confecção dos modelos de gesso, foi realizada a moldagem do arco superior e inferior dos voluntários com alginato da marca Hydrogum® (Zhermack®, Badia Polesine, Rovigo, Itália), seguindo as orientações do fabricante, e posteriormente foi obtido o registro da mordida com cera 7 (Clássico®, São Paulo, Brasil) para auxiliar o recorte dos modelos. Procedeu-se à desinfecção dos moldes e aguardou-se um tempo de 20 minutos antes de vazar o gesso para o alginato terminar sua presa. Após este período, procedeu-se ao vazamento do gesso em um período máximo de 1 hora após a obtenção da moldagem. Os dentes e o rebordo alveolar foram vazados com gesso tipo IV da marca Vigodent® (Rio de Janeiro, Brasil) para assegurar maior dureza ao modelo, e a base foi vazada com gesso branco Mossoró® (Rio de Janeiro, Brasil). Os modelos foram recortados segundo as recomendações de Camargo e Mucha (Camargo e Mucha, 1999).

Os modelos de gesso foram escaneados com dois tipos de *scanners* que utilizam diferentes tecnologias: o *scanner* a laser modelo R700 da empresa 3Shape® (Copenhagen, Dinamarca) e o *scanner* por tomografia computadorizada, Flash CT scanner® (modelo FCT-1600, Hytec Inc.®, Los Alamos, Novo México, EUA) com resolução de voxel de 0,05 mm, da empresa OrthoProof® (Nieuwegein, Holanda).

Para o escaneamento a laser dos modelos foi utilizado o programa “Scan it orthodontics” da empresa 3Shape. Durante o processo de digitalização, a plataforma do scanner move o modelo, para que o laser o atinja em vários ângulos. A luz é projetada sobre o modelo, e as câmeras capturam sua reflexão. A sequência de escaneamento dos modelos consistiu em escanear o modelo superior, em seguida o modelo inferior, posteriormente os modelos ocluídos, para obter a relação interarcos dos modelos digitais, ajuste sagital, vertical e transversal da intercuspidação, acabamento e criação das bases virtuais superior e inferior (Figura 1).

Figura 1: Sequência de escaneamento de modelos de gesso no scanner R700 (3Shape). (A) Escaneamento do modelo superior, (B) Escaneamento do modelo inferior, (C) Escaneamento dos modelos em oclusão.

O escaneamento de modelos por tomografia na empresa OrthoProof foi obtido pelo escaneamento simultâneo do registro de mordida e dos modelos superior e inferior não ocluídos. Após o escaneamento dos modelos, a oclusão foi determinada digitalmente a partir do registro de mordida.

2.1.2 - Moldagem em silicone de adição e escaneamento

A moldagem em silicone de adição dos voluntários foi realizada com a técnica em duas etapas primeiro moldando com a massa pesada. Criou-se um alívio e realizou-se moldagem com a pasta leve para melhor obtenção dos detalhes anatômicos dos dentes. Utilizou-se o material Futura da marca Nova DFL® (Rio de Janeiro, Brasil). Convencionou-se a utilização da pasta leve com viscosidade regular para o arco superior e a pasta leve com viscosidade leve para o arco inferior, com o objetivo de avaliar possíveis diferenças entre os modelos digitais oriundos dos dois tipos de materiais. Após a moldagem dos arcos superior e inferior, foi obtido o registro de mordida com a massa pesada do silicone de adição para auxiliar a correta relação interarcos dos respectivos modelos digitais superior e inferior.

Após a realização da moldagem, os moldes e o registro de mordida de cada voluntário foram acondicionados em recipientes plásticos para posterior escaneamento e obtenção dos modelos digitais. Os 30 pares de moldes foram escaneados formando 3 grupos de 10 pares de moldes de acordo com o período pós-moldagem: T5 (escaneado 5 dias após moldagem), T10 (escaneado 10 dias após moldagem) e T15 (escaneado 15 dias após moldagem).

O escaneamento das moldagens e do registro de mordida em silicone de adição dos voluntários foi realizado com o scanner R700 (3Shape). Para o escaneamento das moldagens foi utilizado o programa “Scan it ortho impression” da empresa 3Shape e a sequência de escaneamento consistiu em escanear o molde superior, em seguida o molde inferior, em seguida o registro de mordida (Figura 2). A partir daí foi realizado o recorte dos excessos dos modelos superior e inferior, alinhamento de três pontos entre o modelo superior e o registro de mordida, alinhamento de três pontos entre o modelo inferior e o registro de mordida, ajuste sagital, vertical e transversal da intercuspidação, acabamento e criação das bases virtuais superior e inferior. As fotografias intrabucais também auxiliaram a visualização da intercuspidação correta entre os modelos digitais.

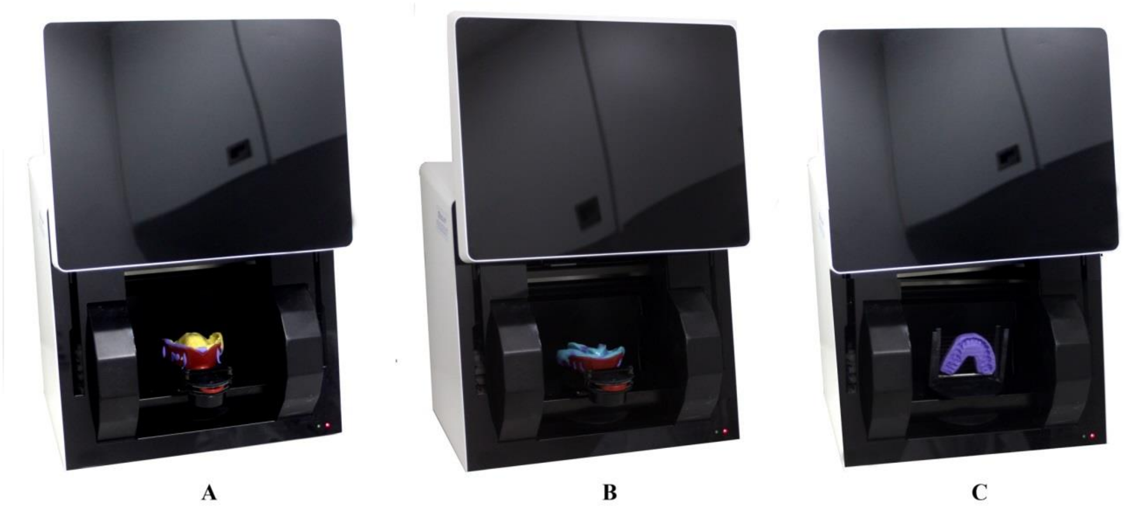


Figura 2: Sequência de escaneamento de moldagens em silicone de adição com scanner R700 (3Shape). (A) Escaneamento do molde superior, (B) Escaneamento do molde inferior, (C) Escaneamento do registro de mordida.

2.1.3 Escaneamento intrabucal da oclusão

Para o escaneamento intrabucal dos voluntários, foi utilizado o scanner TRIOS Color® (3Shape). O sistema TRIOS captura os detalhes anatômicos das estruturas presentes na cavidade bucal sem a necessidade de aplicação de qualquer produto ou pó que cubram os dentes do paciente, o que é considerado uma vantagem em comparação a outros scanners intrabucais. A sequência de escaneamento consistiu em escanear o arco superior, posicionando o scanner sobre os dentes em suas faces oclusal, vestibular e lingual, da região posterior para a anterior. A seguir foi escaneado o arco inferior da mesma maneira. Durante o escaneamento aparece no monitor um quadro com cor verde (captura ótima), amarelo (captura regular – o scanner pode estar sendo movido muito rápido) ou vermelho (não há captura de imagem). Após o escaneamento de ambos os arcos, o voluntário foi orientado a ocluir em máxima intercuspidação para que a oclusão fosse escaneada por vestibular em ambos os lados. O próprio programa do scanner uniu os arcos em oclusão e após sua finalização, os modelos digitais foram enviados ao computador do pesquisador para arquivamento (Figura 3).

Figura 3: Modelo digital armazenado em scanner intrabucal Trios Color (3Shape).

2.2 - Método

2.2.1 - Medições nos modelos de gesso e nos modelos digitais

Realizaram-se as seguintes medições tanto nos modelos de gesso como nos modelos digitais:

- Diâmetro mesiodistal de 1º molar a 1º molar superior e inferior (maior diâmetro mesiodistal do ponto de contato mesial ao ponto de contato distal, paralelo ao plano oclusal)
- Altura da coroa de 1º molar a 1º molar superior e inferior (distância da borda incisal ou ponta de cúspide à margem gengival mais cervical, a partir do eixo vestibular da coroa clínica (Andrews) de cada elemento dentário.
- Distância intercanino superior (distância compreendida entre a ponta de cúspide do canino superior esquerdo à ponta de cúspide do canino superior direito)

- Distância intermolar superior (distância compreendida entre a ponta da cúspide mesiovestibular do 1º molar superior esquerdo à ponta de cúspide mesiovestibular do 1º molar superior direito)
- Distância intercanino inferior (distância compreendida entre a ponta de cúspide do canino inferior esquerdo à ponta de cúspide do canino inferior direito)
- Distância intermolar inferior (distância compreendida entre a ponta da cúspide mesiovestibular do 1º molar inferior esquerdo à ponta de cúspide mesiovestibular do 1º molar inferior direito)
- Overjet (distância do meio da borda incisal mais próximo à face vestibular do incisivo central superior direito à face vestibular do incisivo inferior antagonista, paralelo ao plano oclusal)
- Overbite (distância vertical entre o ponto onde a borda incisal do incisivo central superior direito se sobrepõe à face vestibular do incisivo inferior antagonista até a sua respectiva borda incisal)
- Relação sagital interarcos direita 1 (distância da ponta de cúspide do canino superior direito até o ponto onde a cúspide mesiovestibular do 1º molar superior direito oclui com o arco inferior)
- Relação sagital interarcos esquerda 1 (distância da ponta de cúspide do canino superior esquerdo até o ponto onde a cúspide mesiovestibular do 1º molar superior esquerdo oclui com o arco inferior)
- Relação sagital interarcos direita 2 (distância da ponta de cúspide do canino superior direito até o ponto de encontro entre a margem cervical e o prolongamento do sulco mesiovestibular do 1º molar inferior direito)
- Relação sagital interarcos esquerda 2 (distância da ponta de cúspide do canino superior esquerdo até o ponto de encontro entre a margem cervical e o prolongamento do sulco mesiovestibular do 1º molar inferior esquerdo)

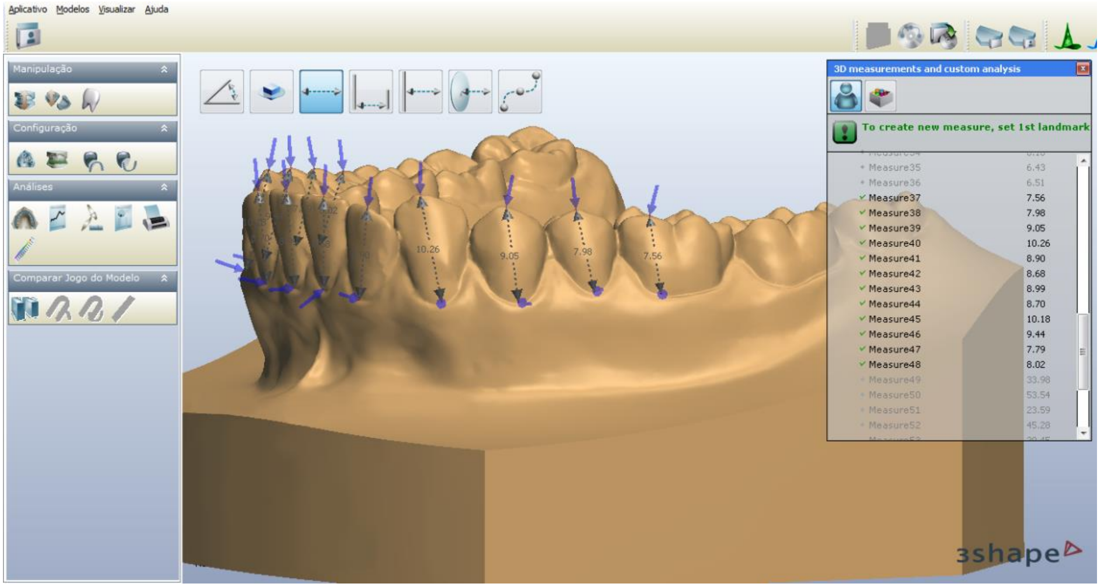
Os modelos de gesso foram considerados como “padrão ouro” para as medições realizadas neste trabalho. A realização de medições em modelos de gesso é mais confortável para o examinador, que pode manipular o modelo sentado em uma mesa sob excelente iluminação e utilizar ferramentas apropriadas para medição (Ovsenik, 2007), enquanto que em uma medição intrabucal é clinicamente difícil obter as medidas exatas dos dentes para poder ser utilizado como “padrão ouro” (Stevens et al., 2006). A coleta dos dados na medição intrabucal pode ser desconfortável para o paciente, principalmente para quem tem limitação de abertura de boca, além de ser necessária a presença do voluntário pertencente à amostra para realização das medidas, o que torna a coleta dos dados sujeita à sua disponibilidade de tempo. Outro argumento que favoreceu a medição nos modelos de gesso foi a necessidade de realização do erro do método, onde seria necessário medir novamente muitos indivíduos da amostra. Um estudo de Ovsenik (Ovsenik, 2007), utilizando um índice para avaliar o grau de severidade de más oclusões, não encontrou diferenças estatisticamente significantes entre medições em modelos de gesso ou intrabucais.

Vários estudos (Santoro et al., 2003; Quimby et al., 2004; Naidu et al., 2009) demonstraram que o paquímetro é um instrumento de medição preciso e confiável, podendo ser considerado como padrão ouro para medições de diâmetros dentários. As medições nos modelos de gesso foram realizadas com os paquímetros digitais Starrett® (Itú, São Paulo, Brasil) e Tesa SA® (Renens, Suíça), que possuem acurácia de 0,01 mm.

Os modelos digitais foram importados para um computador e medidos por meio de programas de manipulação de modelos virtuais. Os modelos digitais por escaneamento do modelo de gesso, pelos scanners das empresas 3Shape e OrthoProof, foram medidos por dois diferentes programas: Ortho Analyzer® (3Shape) e Digimodel® (OrthoProof). Os modelos digitais obtidos pelo escaneamento de moldagens em silicone de adição e pelo escaneamento intrabucal somente foram medidos pelo programa Ortho Analyzer (3Shape).

Em um programa de manipulação os modelos digitais podem ser visualizados em oclusão ou individualmente e podem ser girados e aproximados por zoom para facilitar a identificação dos pontos com precisão de 0,01 mm. Os diâmetros mesiodistais dos dentes foram medidos por cliques do mouse na maior distância entre os pontos de contato mesial e distal, por uma visão oclusal, por ser considerada a melhor técnica de medição (Horton et al., 2010).

A determinação da altura da coroa clínica foi medida da borda incisal ou ponta de cúspide à margem gengival mais cervical, a partir do eixo vestibular da coroa clínica de cada elemento dentário. Para isto foi utilizada a visão frontal e lateral dos modelos (Figura 4). Para medir as distâncias intercaninos superior e inferior e intermolares superior e inferior foi utilizada a visão oclusal e para a medição das relações sagitais foram utilizadas as visões laterais direita e esquerda. O overjet e overbite foram medidos por meio da ferramenta de secção digital do modelo, utilizando o centro do elemento 11 como referência para quantificar sua relação com o dente antagonista.



To create new measure, set 1st landmark

Measure35	6.43
Measure36	6.51
✓ Measure37	7.56
✓ Measure38	7.98
✓ Measure39	9.05
✓ Measure40	10.26
✓ Measure41	8.90
✓ Measure42	8.68
✓ Measure43	8.99
✓ Measure44	8.70
✓ Measure45	10.18
✓ Measure46	9.44
✓ Measure47	7.79
✓ Measure48	8.02
Measure49	33.98
Measure50	53.54
Measure51	23.59
Measure52	45.28

Figura 4: Medição da altura da coroa dos dentes do arco inferior com o programa Ortho Analyzer (3Shape).

2.2.2 – Comparações realizadas entre os modelos de gesso e os modelos digitais e análise estatística

Realizaram-se as seguintes comparações tendo como padrão de referência o modelo de gesso.

2.2.2.1 - Comparação entre modelos de gesso e modelos digitais a partir do escaneamento dos modelos de gesso por dois tipos de scanners: 3Shape e OrthoProof.

Neste estudo, os modelos de gesso foram medidos com o paquímetro Tesa SA® (Renens, Suíça) e os modelos digitais foram medidos por dois programas de medição (Ortho Analyzer e Digimodels), para também avaliar a influência do programa de medição na acurácia e confiabilidade dos modelos digitais. Dois examinadores devidamente calibrados realizaram as medições nos modelos de gesso e digitais. A análise estatística do estudo foi realizada por meio do programa SPSS® versão 20.0 (IBM®, Armonk, NY, EUA). O teste *t* pareado foi utilizado para quantificar o erro intra-examinador e comparar os modelos de gesso e digitais pelos dois examinadores. A influência dos diferentes programas de medição também foi avaliada pelo teste *t* pareado. O coeficiente de correlação de Pearson avaliou a confiabilidade de medidas entre os examinadores em cada tipo de modelo. Os resultados foram considerados significantes com um valor de *p* menor que 0,05.

2.2.2.2 - Comparação entre modelos de gesso e modelos digitais por escaneamento de moldagem em silicone de adição

Neste estudo, os modelos de gesso foram medidos com o paquímetro da marca Starrett® (Itú, São Paulo, Brasil) e os modelos digitais foram medidos pelo programa Ortho Analyzer. Três examinadores devidamente calibrados realizaram as medições do estudo nos modelos de gesso e digitais. Utilizou-se o material Futura da marca Nova DFL (Rio de Janeiro, Brasil). Utilizou-se a pasta leve com viscosidade regular para o arco superior e a pasta leve com viscosidade leve para o arco inferior, com o objetivo de avaliar possíveis diferenças de acurácia entre os modelos digitais oriundos dos dois tipos de materiais. As moldagens e o registro de mordida de cada voluntário foram acondicionados em recipientes plásticos ao abrigo da luz e divididos em 3 grupos de 10 voluntários cada de acordo com o tempo entre a obtenção da moldagem e o respectivo escaneamento. Os tempos determinados foram de 5, 10 e 15 dias. A análise estatística foi realizada por meio do programa SPSS versão 20.0 (IBM). O teste *t* pareado foi utilizado para avaliar o erro intra-examinador e comparar os modelos de gesso e os modelos digitais pelos três examinadores. Foi avaliado também a acurácia dos modelos digitais nos três diferentes períodos pós-moldagem estabelecidos, e a diferença entre os dois tipos de pasta leve utilizadas (leve e regular), por meio do teste *t* pareado. O coeficiente de correlação intraclasse (CCI) avaliou a confiabilidade de medidas entre os examinadores em cada tipo de modelo. Os resultados foram considerados significantes com um valor de *p* menor que 0,05.

2.2.2.3 - Comparação entre modelos de gesso e modelos digitais por escaneamento intrabucal

Neste estudo, os modelos de gesso foram medidos com o paquímetro da marca Starrett (Itú, São Paulo, Brasil) e os modelos digitais foram medidos pelo programa Ortho Analyzer. Dois examinadores devidamente calibrados realizaram as medições do estudo nos modelos de gesso e digitais. A análise estatística do estudo foi realizada por meio do programa SPSS versão 20.0 (IBM). O teste *t* pareado foi utilizado para avaliar o erro intra-examinador e comparar os modelos de gesso e digitais pelos dois examinadores. Uma fórmula baseada no erro intra-examinador e na diferença entre os modelos de gesso e digitais foi desenvolvida para calcular o valor de *p* para determinar o percentual de possibilidade de erros com significância clínica entre os modelos a partir de limites críticos pré-determinados.

2.2.2.4 – Características em comum entre os estudos

A medição direta em modelos de gesso ou em modelos digitais é inevitavelmente associada com algum grau de imprecisão. O erro da técnica de medição provavelmente está na identificação do ponto, e não em função da ferramenta de medição ou do programa selecionado, no caso dos modelos digitais. As medidas manuais com o paquímetro digital dependem do correto posicionamento das extremidades da ponta do paquímetro no modelo de gesso. Para medições digitais, o examinador deve indicar corretamente na tela do computador os dois pontos a serem conectados, como o diâmetro de um dente. Portanto todos os examinadores foram treinados e calibrados antes de realizar as medições. Para isso parte da amostra foi medida por todos os examinadores como um estudo piloto e os resultados foram analisados e discutidos para identificar as concordâncias e discordâncias do método de medição utilizado pelos examinadores, auxiliando assim sua padronização.

Tanto as medições feitas manualmente em modelos de gesso ou digitalmente em um computador estão sujeitos à variabilidade intra-examinador e interexaminadores. Neste caso, a verificação do erro intra-examinador e interexaminadores é fundamental para avaliar a calibração entre os examinadores. Todos os examinadores repetiram após 15 dias, as medições de um terço da amostra selecionada de forma aleatória para realização do erro do método.

3 - ARTIGOS PRODUZIDOS

3.1 - Artigo 1 - Aceito para publicação no American Journal of Orthodontics and Dentofacial Orthopedics.

Title: Effect of PVS material and impression handling on the accuracy of digital models.

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Key words: Digital model, dental measurement, scanning, orthodontics

ABSTRACT

Introduction: The objective of this study was to evaluate the accuracy and reliability of measurements on digital models obtained by scanning impressions 5, 10, and 15 days after they were made from two soft putty polyvinylsiloxane (PVS) materials. **Methods:** Thirty volunteers were selected for making impressions of their dentition with alginate to create a plaster model and with PVS impression material to create a digital model by laser scanning. Three examiners performed plaster model measurements with digital calipers and repeated these measurements on the digital models made from the scanned PVS impressions. A total of 34 distances were evaluated. Paired *t* tests were used to evaluate intra-examiner error and the accuracy of the digital model measurements. Measurement reproducibility and reliability among examiners were tested. **Results:** Although statistically significant differences between measurements on plaster models and digital models were found, these discrepancies were not clinically significant except for overbite. Both plaster models and digital models had high intraclass correlation coefficient values. **Conclusions:** Digital models acquired by laser scanning of two types of soft putty PVS material may be used with clinically acceptable accuracy, reliability, and reproducibility, even at a post-scanning interval of 15 days.

INTRODUCTION

Digital models are increasingly used in clinical orthodontics because of their advantages, such as ease of data storage, transmission, orthodontic diagnosis, and treatment planning and appliance fabrication.[1-11] The demand for digital models is growing because they can be used for a digital setup that then can serve for fabrication of esthetic aligners,[12-14] and other custom appliances such as Insignia® (Ormco®, Orange, California, USA), Incognito® (3M Unitek®, Seefeld, Germany), and Sure Smile® (Stratos/Orametrix Inc.®, Dallas, Texas, USA),[15] and for planning surgical treatment.[16] Scientific information about the accuracy of digital models made from plaster models, impressions, or intraoral scanning is needed. Several studies have evaluated the accuracy and reliability of digital models obtained through different scanning processes, such as plaster model laser scanning,[2,3,5,6,17-25] alginate and polyvinylsiloxane (PVS) impression laser scanning,[18,26-28] computerized tomography scanning of impressions,[8-11] and intraoral laser scanning.[7,8,29,30] The authors of most of these studies did not identify clinically significant differences in measurements on digital models compared with measurements on plaster dental models. Only a few studies have reported clinically significant differences between plaster and digital models.[9,10,22]

For occlusion registration of digital models, it is necessary to scan the bite registration.[8,10] The accuracy of digital models and their occlusion obtained by impression laser scanning has been evaluated in previous studies both for alginate[8-11,26] and PVS impressions.[10,18,27,28] Few studies have investigated surface laser scanning for PVS impressions, and the influence of different types of soft putty PVS material and its dimensional stability on the accuracy of digital models has not yet been reported.

The first objective of this study was to evaluate the accuracy and reliability of digital models obtained by PVS impression scanning, using a surface laser scanner (R700, 3Shape®, Copenhagen, Denmark) and Ortho Analyzer® software (3Shape, Copenhagen, Denmark) as a measurement tool. The second objective was to evaluate how the time elapsed between the impression procedure and the actual scanning of the impression influences the accuracy of digital models. Our third objective was to evaluate the influence of the type of soft putty PVS material on the accuracy of these digital models.

MATERIAL AND METHODS

A sample size calculation was performed using the formula described by Pandis,[31] considering a power test of 90% and α of 0.05, to detect a difference in measurement of 1 mm (SD, 1.16 mm). The sample size calculation (with 10 volunteers) showed that at least 29 volunteers would be needed for the research. This study was approved by the local ethical committee of the Medical School of Federal Fluminense University on February 1, 2013 (registration number 221.664).

Inclusion criteria were fully erupted permanent dentition (including all maxillary and mandibular permanent first molars); no anomalies in number, size, or shape of the dentition; no accentuated recessions, abrasions, or erosions; no cavities or restorations that could compromise thei mesiodistal diameter; and no orthodontic fixed retention.

Thirty volunteers who met the inclusion criteria were selected at the Department of Orthodontics of Federal Fluminense University. Their ages ranged from 21 to 39 years, with a mean of 27 years and 9 months. All volunteers were informed about the research procedures and signed informed consent. After a clinical examination, alginate impressions with Hydrogum® alginate (Zhermack®, Badia Polesine, Rovigo, Italy) were made following the manufacturer’s guidelines. In addition, a bite registration in maximal occlusion was made using a number 7 dental wax (Clássico®, São Paulo, Brazil). Twenty minutes after impression taking, to complete the alginate cure period, the alginate impressions were disinfected and placed in a closed plastic bag. Within 1 hour after impression taking, the teeth and the alveolar ridges were covered with type IV plaster (Vigodent®, Rio de Janeiro, Brazil). The base of the model was poured with white plaster (Mossoró®, Rio de Janeiro, Brazil).

Directly after the making of the alginate impression, a PVS impression was taken from each volunteer. These PVS impressions of the both arches were taken using the 2-step technique with Futura impression material (Nova DFL®, Rio de Janeiro, Brazil). The first impression was made with the heavy putty material, and then the soft putty material was used to record the anatomical details, according to the manufacturer’s guidelines. The regular-viscosity soft putty was used for the maxillary arch and the light-viscosity soft putty for the mandibular arch to allow evaluation of possible accuracy differences between the 2 materials. After both impressions were taken, a bite registration in maximum intercuspation was obtained with the PVS heavy putty (Fig 1).

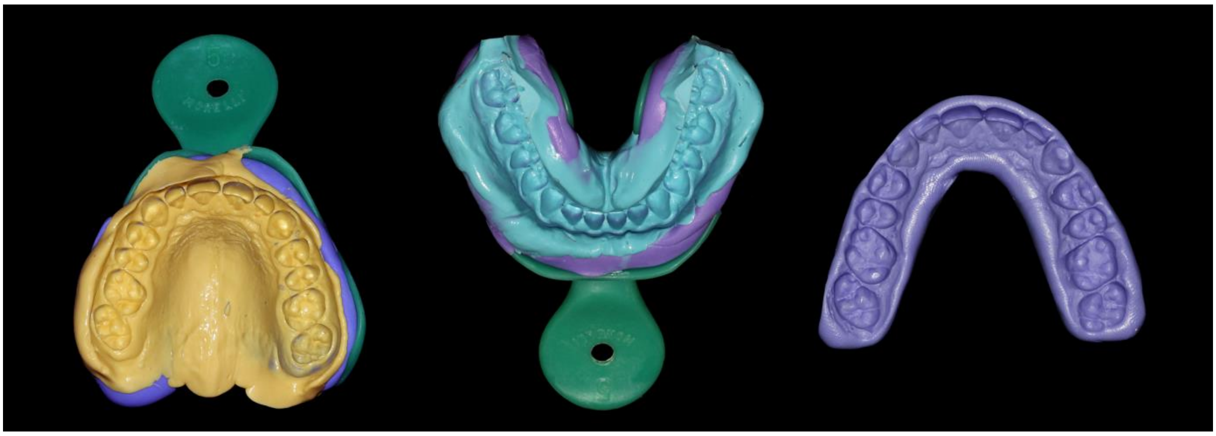


Fig 1. Maxillary impression (regular viscosity), mandibular impression (light viscosity), and bite registration.

After impression taking, the PVS impressions and the bite registration were disinfected, stored in plastic bags, and protected from light for subsequent scanning to obtain digital models. The 60 impressions (30 impressions of each arch) and the respective bite registrations were scanned with the R700 scanner (3Shape, Copenhagen, Denmark), using dedicated impression scanning software. The scanning procedure started with the maxillary impression, followed by the mandibular impression, and then the bite registration was scanned with a device that kept it stable without deforming it. After making the first scan, the scanner automatically detects the areas where the scan has less quality and scans them during the adaptive scanning by turning the table where the impression is and by moving the cameras on the rail. Of course, there are limits in scanning possibilities and time, so it is difficult to scan properly when the areas are not visible because of some undercuts. In some cases, we used a titanium oxide powder on the mandibular incisor area to improve scanning accuracy; the narrower undercuts in this region can create difficulty with the laser incidence of the scanner (Fig 2). For superimposition of the maxillary model and bite registration, 3 points (first molar and incisal regions) on the models were selected along with 3 identical points on the bite registration for the initial alignment. The same procedure was repeated for the mandibular model. The 3Shape software then automatically superimposed both digital models by a best-fit method. Then sagittal, transverse, and vertical adjustments were made to create the virtual maxillary and mandibular bases (Fig 3). The 30 digital model pairs were divided into three groups of 10 pairs each, according to the time interval between taking and scanning the PVS impressions. T5 represented an interval of 5 days; T10, 10 days; and T15, 15 days.

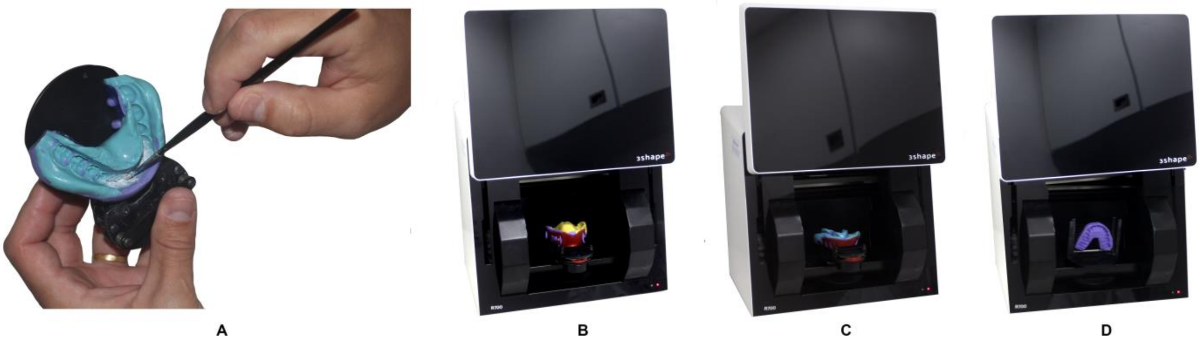


Fig 2. **A**, Application of titanium oxide powder in the mandibular incisor area; **B**, maxillary impression scanning; **C**, mandibular impression scanning; **D**, bite registration scanning.

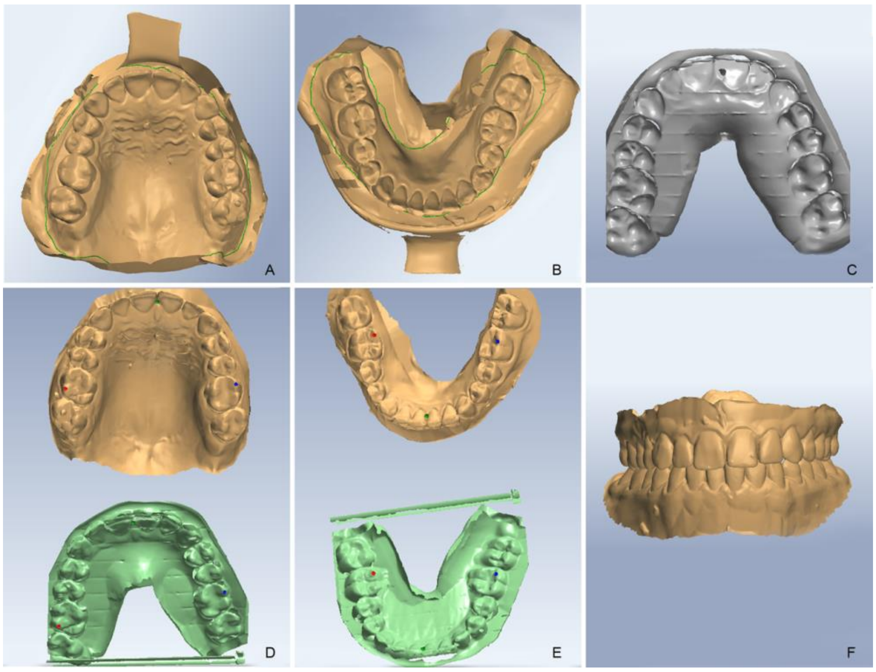


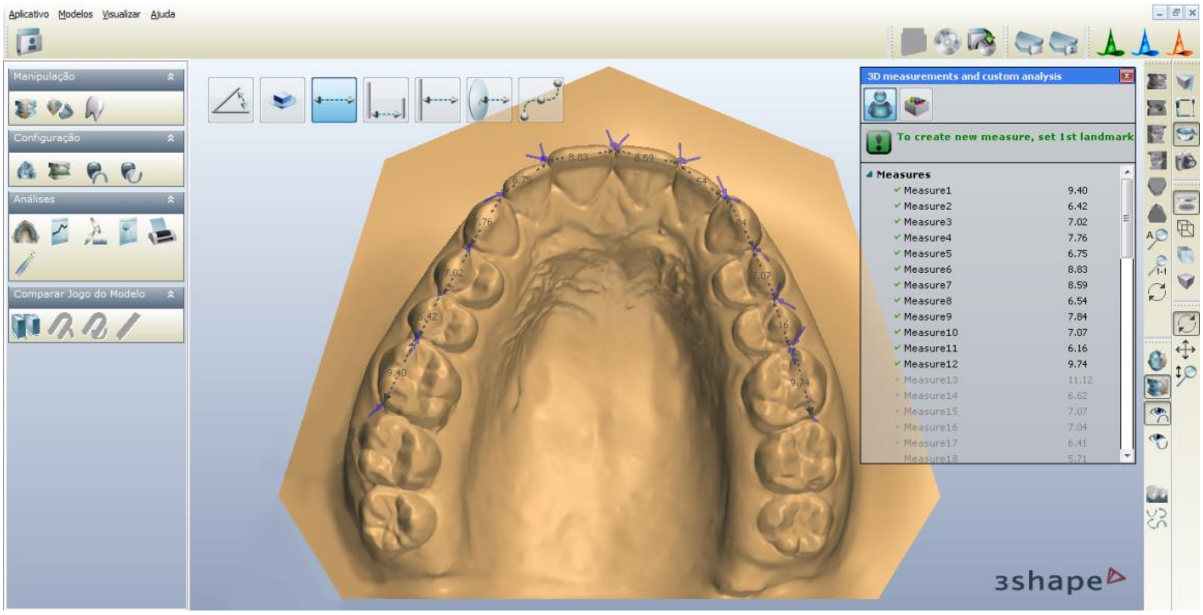
Fig 3. Defining the occlusion: **A**, digital maxillary model; **B**, digital mandibular model; **C**, digital bite registration; **D**, defining points between the maxillary model and the bite registration; **E**, defining points between the mandibular model and the bite registration; **F**, digital model after interarch adjustment.

Thirty-four clinically relevant parameters for measuring were defined for each pair of dental models, including tooth diameter, transverse distances (upper and lower intercanine and intermolar distances), and interarch relationship measurements (overbite, overjet) (Table I). Three examiners were properly trained to measure the plaster and digital models before the start of the study. Among the examiners was an undergraduate student of dentistry, a master student of orthodontics, and a doctoral student of dentistry. The plaster models were measured using a digital caliper (Starrett®, Itu, São Paulo, Brazil), with an accuracy of 0.01 mm. The digital models where measured using the Ortho Analyzer® software with the direct measuring tool (Fig 4). To calculate method error, the 3 examiners repeated the measurements on 10 randomly selected plaster models and 10 digital models, 15 days after the first measurement.

Table I. Measurement definitions

Mesurement	Abbreviation	Definition
Mesiodistal diameter	MDD	Maxillary and mandibular mesiodistal diameter from first molar to first molar (higher mesiodistal diameter of the contact point mesial to distal point of contact, parallel to the occlusal plane)
Sum of maxillary 6 teeth	Sum maxillary 6	Diameter sum of 6 anterior maxillary teeth
Sum of maxillary 12 teeth	Sum maxillary 12	Diameter sum of 12 anterior maxillary teeth
Sum of mandibular 6 teeth	Sum mandibular 6	Diameter sum of 6 anterior mandibular teeth
Sum of mandibular 12 teeth	Sum mandibular 12	Diameter sum of 12 anterior mandibular teeth
Maxillary intercanine distance	Maxillary ICD	Distance between the cusp tip of the maxillary left canine to cusp tip of the maxillary right canine
Maxillary intermolar distance	Maxillary IMD	Distance between the tip of the mesiobuccal cusp of the maxillary left first molar to the tip of the mesiobuccal cusp of the maxillary right first molar
Mandibular intercanine distance	Mandibular ICD	Distance between the cusp tip of the mandibular left mandibular canine to cusp tip of the mandibular right canine
Mandibular intermolar distance	Mandibular IMD	Distance between the tip of the mesiobuccal cusp of the mandibular left first molar to the tip of the mesiobuccal cusp of the mandibular right first molar
Overjet	Overjet	Distance from the middle of the incisal edge closest to the buccal surface of the maxillary right maxillary central

		incisor to the buccal surface of the mandibular incisor antagonist, parallel to the occlusal plane
Overbite	Overbite	Vertical distance between the marking where the incisal edge of the maxillary right central incisor overlaps the buccal surface of the mandibular incisor antagonist until its respective incisal edge



To create new measure, set 1st landmark

Measures	
✓ Measure1	9.40
✓ Measure2	6.42
✓ Measure3	7.02
✓ Measure4	7.76
✓ Measure5	6.75
✓ Measure6	8.83
✓ Measure7	8.59
✓ Measure8	6.54
✓ Measure9	7.84
✓ Measure10	7.07
✓ Measure11	6.16
✓ Measure12	9.74
Measure13	11.12
Measure14	6.62
Measure15	7.07
Measure16	7.04
Measure17	6.41
Measure18	5.71

Fig 4. Measuring tooth diameters on a digital model with Ortho Analyzer software.

All plaster models of the sample were also scanned with the same scanner (R700) to acquire the respective digital models and enable a comparison with digital models from PVS impression scanning. They were compared using a superimposition method by Geomagic Qualify® software (3D Systems®, Rock Hill, South Carolina, USA). The bases of the 2 types of digital models were cut apical to the gingival margin. The models were aligned with the dentition using the best-fit surface alignment tool. After alignment, the model edges were trimmed with cutting planes to create common borders. Color displacement maps were generated to confirm accurate crown superimpositions and measure differences between the models. Geomagic Qualify software outputs the mean and maximum displacements, the positive and negative average differences, and the standard deviations measured in the color map analysis. These data are obtained by a calculation of the distances of points between each digital model superimposed. The limits used in the color map were 0.25 mm (Fig 5). Figures 6 and 7 illustrate the design of the study.

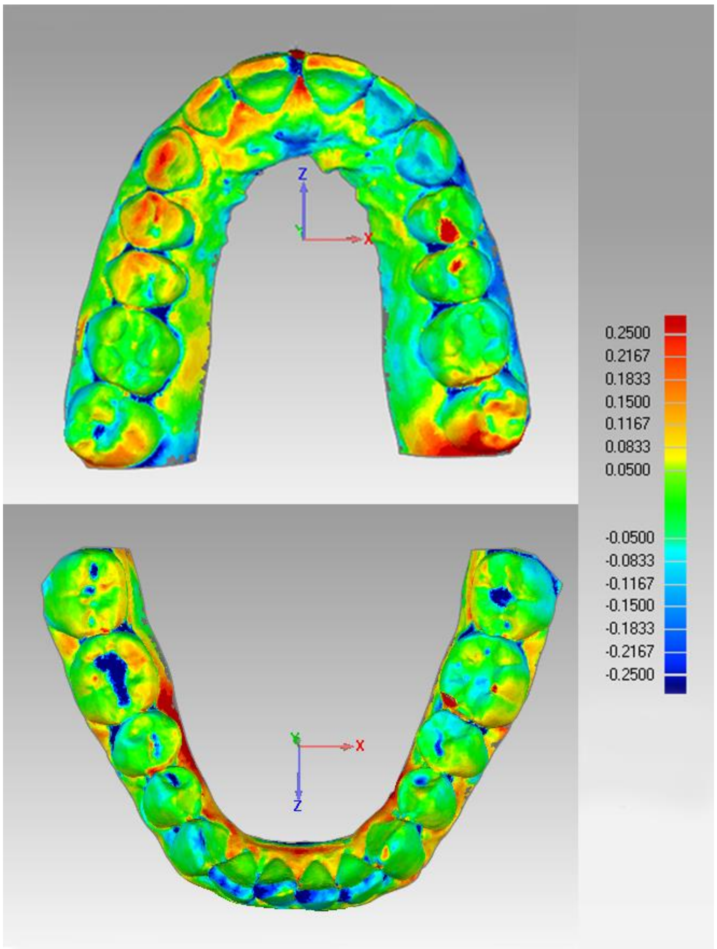


Fig 5. Evaluation of the accuracy by superimposition of the digital models with Geomagic Qualify software.

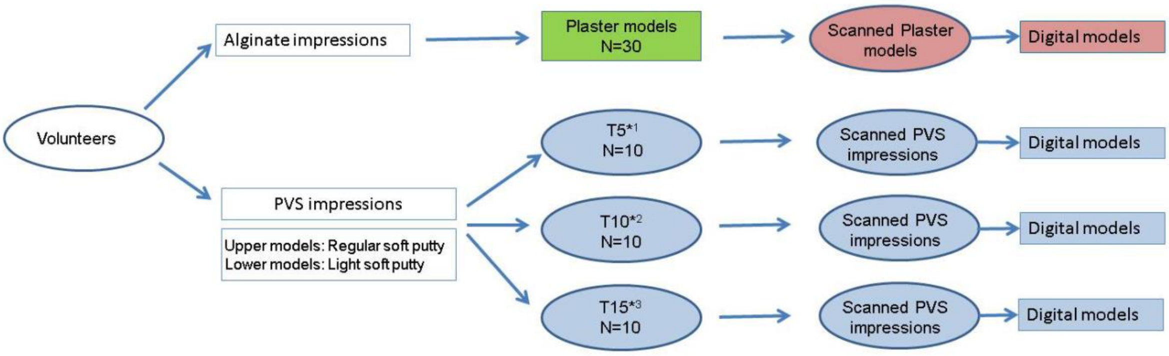


Fig 6. Schematic figure showing the procedures used in the study (*1 - T5: 5 days after impression taking; *2 - T10: 10 days after impression taking; *3 - T15: 15 days after impression taking).

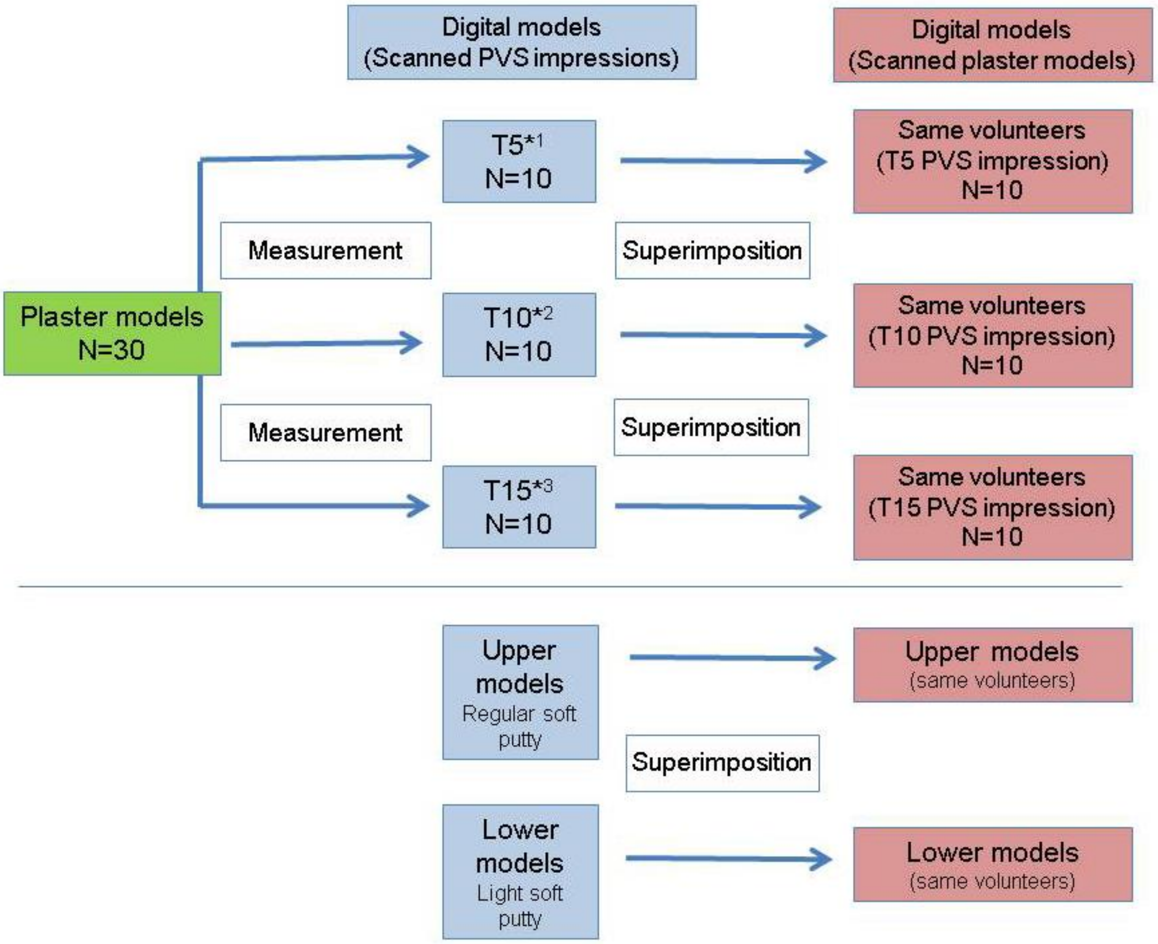


Fig 7. Schematic figure showing the comparisons made in the study (*1 - T5: 5 days after impression taking; *2 - T10: 10 days after impression taking; *3 - T15: 15 days after impression taking).

Statistical analysis

Statistical analysis was performed with SPSS software for Windows (version 20.0, IBM®, Armonk, NY, USA). The paired *t* test was used to compare measurements on plaster models and digital models by PVS impression scanning for each examiner. The intraclass correlation coefficient (ICC) evaluated the reproducibility of the measurements among the examiners for each model. The paired *t* test was also used to compare the differences by superimposition of the digital models (plaster model scanning vs. PVS impression scanning), according to the time interval of impression taking. The differences between soft putty types were compared by paired *t* tests of superimposition differences between the maxillary models (regular viscosity) and the mandibular models (light viscosity), by also using the superimposition between plaster model scanning and PVS impression scanning for each maxillary and mandibular models. Differences in measurement were considered to be statistically significant if the *p*-value was lower than 0.05.

The method error was calculated by comparing the initial measurements and the measurements after 15 days for the selected sample. The paired *t* test was used to evaluate the intra-examiner error. Results were considered to be significant when the *p*-value was lower than 0.05.

RESULTS

The intraexaminer errors of each examiner had low values, and all examiners had lower error values in the plaster models compared to the digital models by PVS impression scanning. Examiner 1 had a mean difference of all parameters of 0.08 mm for digital models (maximum error in the sum of 12 lower teeth of 1.88 mm) and an average difference of -0.01 mm in all parameters of plaster models (maximum error in the diameter of element 15 of -1.06 mm). Examiner 2 had a mean difference in the error values of 0.05 mm in all parameters of digital models (maximum error in the sum of 12 lower teeth of 0.99 mm), and the average differences in all parameter in plaster models were -0.01 mm (maximum error in the maxillary intercanine distance of -1.24 mm). Examiner 3 had similar results to those of examiner 2, 0.05 mm in the average differences in all parameters of digital models (maximum error of 1.06 mm in the sum of mandibular 12 teeth) and -0.01 mm in the plaster model’s mean differences of all parameter (maximum error of 0.21 mm in the sum of 12 lower teeth).

The reproducibility analysis showed high ICC values for both plaster model measurements (r = 0.908) and those on digital models (r = 0.857). Transverse measurements had high ICC values for plaster models (r = 0.966) and digital models (r = 0.976). Overbite and overjet also showed high ICC values for plaster models (0.965 and 0.930) and digital models (0.970 and 0.943). In relation to tooth diameter, plaster models had higher ICC values (maxillary teeth, 0.891; mandibular teeth, 0.881) than the digital models (0.827 and 0.800) (Table II).

Table II: Correlation among examiners on plaster models vs digital models

Parameter	Plaster model N = 30		Digital model PVS impression N = 30	
	Intraclass Correlation Coeficient	95% Confidence Interval	Intraclass Correlation Coeficient	95% Confidence Interval
MDD maxillary teeth (Mean)	0.891	*0.814 - 0.942*	0.827	*0.714 – 0.906*
Sum maxillary 6	0.967	*0.940 – 0.983*	0.956	*0.922 – 0.978*
Sum maxillary 12	0.964	*0.936 – 0.982*	0.962	*0.931 – 0.980*
MDD mandibular teeth (mean)	0.881	*0.797 – 0.937*	0.800	*0.673 – 0.890*
Sum mandibular 6	0.953	*0.917 – 0.976*	0.927	*0.871 – 0.962*
Sum mandibular 12	0.967	*0.941 – 0.983*	0.960	*0.929 – 0.980*
Maxillary ICD	0.967	*0.940 – 0.983*	0.971	*0.948 – 0.985*
Mandibular ICD	0.947	*0.906 – 0.973*	0.963	*0.933 – 0.981*
Maxillary IMD	0.987	*0.977 – 0.993*	0.991	*0.984 – 0.996*
Mandibular IMD	0.965	*0.937 – 0.982*	0.980	*0.964 – 0.990*
Overjet	0.930	*0.877 – 0.964*	0.943	*0.898 – 0.970*
Overbite	0.965	*0.936 – 0.982*	0.970	*0.947 – 0.985*

The paired *t* test was used to compare the differences in measurements by each examiner for the plaster and digital models by PVS impression scanning. Statistically significant differences were found for some measurements. Examiners 1 and 3 had similar results, but examiner 2 had more clinically significant differences. The maxillary and mandibular tooth diameters showed that examiners 1 and 3 had similar measurements, whereas examiner 2 registered lower values for the measurements on the digital models. Regarding overjet, the 3 examiners registered similar measurements with small differences, whereas measurements of overbite had lower values for digital models for all examiners. Measurements on digital models showed lower values for all examiners, with average differences between all parameters of 0.022 mm for examiner 1, 0.537 mm for examiner 2, and 0.166 mm for examiner 3 (Table III). The difference in measurements for overbite was clinically significant for almost all of the digital models, with exception of examiner 1 in T5.

Regarding the influence on the accuracy of digital models of the time interval between PVS impression taking and scanning, the paired *t* test showed no significant difference in results among the 3 time periods (5, 10, and 15 days) compared with the plaster model measurements. Table IV shows the differences between the digital models according to the scanning interval time after the PVS impression taking. Digital models by PVS impression scanning of each time interval were superimposed with the respective dental model by plaster model scanning, and the results showed no statistically significant differences in the parameters studied (average differences, positive average differences, and negative average differences).

The type of soft putty had no influence on the accuracy of digital models; the mean differences in maxillary arch superimpositions and mandibular arch superimpositions were not statistically significant (Table V).

Table III: Paired *t* tests mean differences among examiners on plaster models vs digital models

Parameter	Examiner 1			Examiner 2			Examiner 3		
	Mean (mm)	SD (mm)	*P* value	Mean (mm)	SD (mm)	*P* value	Mean (mm)	SD (mm)	*P* value
Sum maxillary 6	0.083	0.819	0.580	2.317	1.000	**0.000**	1.171	0.685	**0.000**
Sum maxillary 12	0.494	1.208	**0.033**	3.386	1.762	**0.000**	1.370	1.141	**0.000**
Sum mandibular 6	-0.159	0.760	0.261	1.448	1.124	**0.000**	0.361	0.858	**0.029**
Sum mandibular 12	-0.382	1.214	0.095	2.151	1.833	**0.000**	0.270	0.963	0.135
Maxillary ICD	0.291	0.497	**0.003**	0.500	0.593	**0.000**	0.447	0.484	**0.000**
Mandibular ICD	-0.320	0.413	**0.000**	0.067	0.807	0.653	-0.272	0.572	**0.014**
Maxillary IMD	0.218	0.363	**0.003**	0.709	0.494	**0.000**	0.092	0.436	0.254
Mandibular IMD	-0.289	0.723	**0.037**	0.831	0.699	**0.000**	0.296	0.633	**0.016**
Overjet	0.104	0.415	0.178	0.479	0.581	**0.000**	-0.248	0.455	**0.006**
Overbite	0.625	0.583	**0.000**	0.852	0.505	**0.000**	0.536	0.541	**0.000**

Table IV: Paired *t* tests mean differences between superimposition of digital models by plaster model scanning and PVS impression scanning according to time after impression taking

	5 days after impression taking		10 days after impression taking		15 days after impression taking		Comparison 5 days vs. 10 days			Comparison 5 days vs. 15 days			Comparison 10 days vs. 15 days		
Arch	Mean differences (mm)	SD (mm)	Mean differences (mm)	SD (mm)	Mean differences (mm)	SD (mm)	Mean differences (mm)	SD (mm)	*P* value	Mean differences (mm)	SD (mm)	*P* value	Mean differences (mm)	SD (mm)	*P* value
	Average differences		Average differences		Average differences		Average differences			Average differences			Average differences		
Upper arch	0.002	0.023	-0.006	0.020	-0.009	0.028	0.009	0.037	0.432	0.012	0.028	0.217	0.002	0.038	0.838
Lower arch	-0.011	0.018	-0.004	0.031	-0.002	0.015	-0.007	0.042	0.571	-0.009	0.020	0.163	-0.001	0.034	0.867
	Positive average differences		Positive average differences		Positive average differences		Positive average differences			Positive average differences			Positive average differences		
Upper arch	0.128	0.080	0.127	0.045	0.119	0.030	0.000	0.102	0.986	0.008	0.102	0.793	0.008	0.051	0.630
Lower arch	0.093	0.020	0.116	0.045	0.109	0.037	-0.023	0.046	0.144	-0.016	0.040	0.224	0.006	0.059	0.726
	Negative average differences		Negative average differences		Negative average differences		Negative average differences			Negative average differences			Negative average differences		
Upper arch	-0.146	0.793	-0.151	0.048	-0.151	0.028	0.005	0.098	0.863	0.005	0.099	0.875	-0.000	0.056	0.982
Lower arch	-0.127	0.023	-0.135	0.035	-0.136	0.034	0.007	0.043	0.596	0.008	0.050	0.592	0.001	0.026	0.887

Table V: Paired *t* tests mean differences between superimposition of digital models by plaster model scanning vs. PVS impression scanning, on both arches

Parameter	Maxillary arch superimposion differences (mm) N = 30		Mandibular arch superimposion differences (mm) N = 30		Mean difference of upper and lower arch superimpositions (mm)	SD (mm)	*P* value
	Mean	SD	Mean	SD			
Average differences	-0.004	0.024	-0.006	0.022	0.001	0.033	0.806
Positive average differences	0.125	0.054	0.106	0.035	0.018	0.061	0.110
Negative average differences	-0.149	0.054	-0.133	0.031	-0.016	0.058	0.131

DISCUSSION

The results of this study demonstrate a high accuracy and reliability for digital models based on PVS impression scanning compared to plaster models, as has previously been reported.[8-11,18,26-28] The plaster models of the dentition are also a copy of the dentition and may not represent actual measurements of natural teeth because of possible dimensional changes in the impression materials and plaster during their fabrication.[2,9] However, plaster models have been considered the gold standard in research for representing the accuracy of dimensions of the dentition in most studies,[2,3,5,6,17-25] and they have been successfully used in dentistry for over 100 years. Performing measurements on plaster models is more comfortable for the examiner compared to direct measurements of the dentition. A plaster model can be stored, manipulated, and reviewed with excellent lighting and appropriate tools for measurement.[32] Data collection using intraoral measurement with calipers can be uncomfortable for the patient, especially for those with limited mouth opening. Ovsenik[32] found no statistically significant differences between measurements on plaster models or direct intraoral measurements.

Scanning of plaster models can be used to replace plaster models with some advantages. Digital models can reduce the space needed for actual storage of plaster models and the time needed to retrieve plaster models required for evaluation during treatment. Digital models also can be used for making a virtual setup for treatment simulation and for custom appliance fabrication.[15]

In this study, we evaluated the accuracy (proximity between measurements of an object and its real value) and the reliability (repetition and reproducibility of the measurements) of digital models made from PVS impressions with a surface scanner. Measurements on both plaster and digital models are inevitably associated with some degree of imprecision. Errors in measurements of the dentition arise because of several factors. The first is point identification. The location of a specific reference point for measurement may vary among examiners, regardless of the method. This difference in determinations of the reference points on both plaster and digital models has been described previously, and differences in point identification directly affect the reproducibility of the measurements.[2,3,24,27] Another measurement error is related to differences in the measurement tool. Measurements on plaster models are made with calipers, whereas measurements on digital models are made on computer screens using dedicated software. To reduce these errors, researchers need to be trained in indicating the measurement points on both models and performing the measurements on plaster models and in how to use a specific software program for evaluating digital models.[2,5,27,30] In this study, all examiners were trained before the study to indicate points and measure with calipers on the plaster models and to use the Ortho Analyzer software. The high ICC values prove that the measurements were accurate between researchers. A high reproducibility of the measurements on the digital models has also been reported in other studies.[1,8,11,18,27,30]

In accordance with previous reports, for measurements of overjet, overbite, and tooth diameters, average differences above 0.3 mm were considered to be clinically significant, as were transverse measurements with mean differences above 0.4 mm.[5,30,33,34] Although the difference between several measurements was statistically significant, for most of them, the differences were considered clinically insignificant. From the 34 variables evaluated by each examiner, for examiner 1, only 2 clinically significant differences in measurements were found. For examiner 2, there were 16, and for examiner 3, there were 2. These results most likely can be attributable to the difficulty of marking the points exactly as described in the measurement procedure. Markers could solve these problems but are not available for dental models. Examiner 2 had more discrepancies than the other 2 examiners relative to one another, possibly because he was an undergraduate student. Even though all examiners had been trained and calibrated, examiner 2 had less professional experience with measuring models than the other 2 examiners. Examiner 3 had differences in the sum of upper 6 and 12 under 1.5 mm (Table III); these can be considered acceptable, when the average values for the sum of 6 maxillary teeth is 45 mm and the sum of 12 maxillary teeth is 90 mm.

This study has shown that digital models as used here can replace plaster models. On average, measurements on digital models by PVS impression scanning showed lower values compared to measurements on plaster models, which corresponds to the findings of Torassian *et al*.[9] As reported earlier by Santoro *et al*.,[25] the differences in measurements of overbite were clinically significant for all examiners. Two possible explanations for this difference should be mentioned. Compared with measurements on plaster models with calipers, the measurements on digital models with dedicated software are facilitated by the ability to enlarge and rotate the image of the digital model on the computer screen. Furthermore, removal of parts of the digital model, known as “clipping,” is possible. The small cursor, which can be used to mark the selected point for measuring on the dentition, compared with the large dimensions of the calipers used for measurements on plaster models, could make digital measurements of overjet and overbite more accurate.[25] Inaccuracy of the occlusion, especially in relation to the vertical adjustment of the digital models, may have caused relative inaccuracy of the measurements of the overbite in digital models.[8,10]

Another method of comparison is model superimposition, which is not possible in plaster models but can be used in digital models.[29] This method can be applied to evaluate accuracy and reliability of digital models,[29,35] as well as to visualize and quantify teeth movement in an orthodontic treatment.[36] Several types of software are available that can make this superimposition. In this study, we used Geomagic Qualify software, which is applied in metrology. Color-coded displays of the deviations allow qualitative visualization of the differences between the digital models. We used this method to evaluate the accuracy of digital models by PVS impression scanning, according to the interval time from impression taking to scanning and according to the type of soft putty used.

As reported in the literature, the maximum stability of alginate impressions is 5 days.[37] Fabrication of dental setups and custom appliances on 3-dimensional printed dental models requires transportation of dental impressions to a dental laboratory. This transportation and the procedure for acquiring digital models from the impression usually take more than 5 days, and in case of international travel, depend on the transportation options of each country. Thus, in this study, the PVS impression material was used for scanning. We scanned 10 sets of impressions and bite registrations at 5, 10, and 15 days after impression taking. A period of 15 days is the time limit of the PVS material dimensional stability recommended by the manufacturer. We found that PVS impressions scanned in a period up to 15 days with the surface scanner used in this study provided digital models with clinically satisfactory reliability.

For making PVS impressions, the clinician will receive a hard putty material and can select 1 of 2 types of soft putty material with different viscosities. In this study, we used 2 types of soft impression material (regular and light viscosity) to evaluate whether differences in accuracy occurred. We identified no accuracy differences between digital models from PVS impressions made with hard and soft putty with a regular viscosity impression of the maxillary arch and soft putty with a light viscosity impression of the mandibular arch.

The superimposition method of comparison showed fewer differences compared with the measuring method. Superimposition is done by computer software and thus is less subject to misinterpretations. However, the measuring method is important for clinical diagnosis and treatment planning in orthodontics, and this study has shown that both plaster models and digital models by PVS impression scanning can be used safely.

CONCLUSIONS

With the exception of overbite, no measurements on plaster and digital models were considered clinically significantly different. The outcome of this study demonstrates the high accuracy and reliability of digital models by PVS impression scanning in agreement with previous reports in the literature. Furthermore, the acquisition of digital models by surface laser scanning of PVS impressions scanned within 15 days after impression taking resulted in an accurate digital model, regardless of the soft putty viscosity type. Although statistically significant differences were found in measurements between the plaster and digital models, the accuracy and reliability of these digital models are clinically acceptable, except for overbite. Based on the superimposition method of comparison, no statistically significant difference was found. Therefore, these digital models can be used for treatment planning and appliance fabrication in clinical orthodontics.

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3.2 - Artigo 2 – A ser submetido para o European Journal of Orthodontics.

Title: Accuracy and reproducibility of digital dental models created using an intraoral scanner.

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Key words: Digital model, dental measurement, intraoral scanning, orthodontics

ABSTRACT

Background: The present study aimed to evaluate the accuracy and reproducibility of measurements made on digital models created using an intraoral color scanner compared to measurements on dental plaster models. **Methods:** This study included impressions of 28 volunteers. Alginate impressions were used to make plaster models, and the volunteers' dentition was scanned with a TRIOS Color intraoral scanner. Two examiners performed measurements on the plaster models using a digital caliper and measured the digital models using Ortho Analyzer software. The examiners measured 52 distances, including tooth diameter and height, overjet, overbite, intercanine and intermolar distances, and the sagittal relationship. The paired *t* test was used to assess intra-examiner performance and measurement accuracy. The level of clinical significant differences between the methods according to the threshold used was evaluated. **Results:** For some parameters, differences were found between the measurements on the two different models. However, most of these discrepancies were considered clinically insignificant. The measurement of the crown height of upper central incisors had the highest measurement error for both examiners. Based on the interxaminer performance, reproducibility of the measurements was poor for most of the parameters. **Conclusions:** Overall, our findings showed that digital models created using the TRIOS Color Scanner and measured with Ortho Analyzer software can be used with clinically acceptable accuracy compared to the same measurements made with a caliper on plaster models, but the measuring method will affect the reproducibility of the measurements.

INTRODUCTION

Digital models in orthodontics are often obtained via an indirect method that requires the transport of plaster models or impressions of the dentition to a specialized company for laser or CT scanning (1-15). During transportation, it is possible that plaster models can fracture (16) and the dental dimensions of the impressions can change (4, 14). Thus, there is interest in direct methods to copy the dentition. Directly measuring of the dentition with calipers is possible, but this method is difficult and time consuming (4) and does not result in a physical dental model which is available for later use. Cone beam computer tomography (CBCT) radiographs can also be used for dental analysis (5, 15, 17), but this method involves exposing the patient to radiation (15). An alternative that does not involve radiation exposure is the intraoral scanning, which also has the advantage of improved detailing of the dental anatomy compared to CBCT images of the dentition (16).

Intraoral scanners have been recently introduced as a replacement for the dental impression-taking procedure. An intraoral scanner is easy to use, and generates stereolithographic (STL) files that can be used to make digital models. Registration of an occlusion with an intraoral scanner does not require a separate material for bite registration (12, 13). Most patients have reported that the intraoral scanning procedure is more comfortable than conventional impression taking, although some studies have reported the opposite conclusion (18). Currently, the mean time needed for intraoral scanning is shorter than that required for taking traditional PVS impressions (one impression with heavy material and a second impression with soft impression material), but the intraoral scanning time is longer than required for the alginate impression procedure (18). It is expected that improvements of the scanners, the scanning software, and the use of faster computers enable reduction of the scanning time. Although several intraoral scanners have been commercialized for use in orthodontics, only the scanners Lava COS (3M ESPE, St Paul, Minn, USA) and iTero (Align Technologies, San Jose, Calif, EUA) were tested under clinical conditions (19).

The intraoral scanning procedure could be more accurate than traditional impression taking, as intraoral scanning is not prone to some of the errors that can occur in the traditional impression-taking procedure, such as air bubbles, rupture of impression material, inaccurate impression tray dimensions, too much or too little impression material, inappropriate adhesion of the impression to the impression tray, and impression material distortion due to the disinfection procedure (20). Intraoral scanning could also be particularly advantageous for patients with anxiety during impression taking (especially for the upper impression), and for cleft palate patients who could carry an increased risk of impression material aspiration and for whom standard impression trays are not suitable (21). Intraoral scanning could also be an advantage for patients currently undergoing orthodontic treatment with fixed appliances, for whom a traditional impression will be severely distorted because of the presence of orthodontic appliances.

The cost of purchasing an intraoral scanner could be a profitable investment for an orthodontic office, as the intraoral scanning procedure will decrease the need to retake inaccurate dental impressions, as well as the need for impression disinfection and transportation. Additionally, the use of digital models will eliminate the need for dedicated space to store dental plaster models in an orthodontic office. Another advantage is that the digital models are immediately available and can be used to discuss treatment with the patient during the record taking visit. Software for intraoral scanners can be used for digital model analysis, and segmentation software can be used for dental crown segmentation to make a digital dental setup for digital planning of orthodontic treatment. Furthermore, a digital model can be electronically sent to an orthodontic laboratory anywhere in the world to order custom removable or fixed orthodontic appliances. If needed, a physical dental model can be printed using a 3D printer in the orthodontic lab or in the orthodontic office (22).

Several studies have evaluated the accuracy and reliability of making digital models using different acquisition methods, including laser scanning of plaster models (18) laser scanning of impressions (2, 9-11) , CT scanning of impressions (12-15, 18) and intraoral scanning (13, 16, 18, 20, 21, 23, 24). These studies have used different scanners and different software programs, which is limiting comparability of the results. Most of these studies found statistically different measurements of digital models as compared to the same measurements made on plaster models, but few of these measurement differences were clinically significant (12, 14).

The present study aimed to evaluate the accuracy and reproducibility of digital models constructed from the files of intraoral scans of volunteers with the TRIOS Color scanner (3Shape®, Copenhagen, Denmark), which was not studied in the clinical setting (19). Measurements on plaster models of these volunteers were compared to measurements on the digital models with the Ortho Analyzer® software (3Shape®, Copenhagen, Denmark).

MATERIAL AND METHODS

Using plaster models of 10 individuals, a power study was performed applying the formula described by Pandis (25), assuming 90% power and an α of 0.05. This power study showed that a series of dental models and intraoral scans from at least 29 individuals were needed to reveal a 1-mm difference in measurements with a 1.16 mm standard deviation.

Volunteers were recruited at the Department of Orthodontics of Federal Fluminense University. Thirty volunteers included in this study had a fully erupted permanent dentition (including all upper and lower first permanent molars). Exclusion criteria were: dental anomalies in size and shape, severe gingival recessions, dental crown abrasions, attritions and erosions, or fixed orthodontic retention. At the time of impression taking, the volunteers were all between 21 and 39 years of age, with an average age of 27 years. All volunteers were informed about the study procedures, and signed an informed consent form prior to participation. The local ethical committee approved this study (number 221.664) on February 1, 2013.

Participants underwent a clinical examination, after which alginate impressions of the upper and lower arch were made with Hydrogum® (Zhermack, Badia Polesine, Rovigo, Italy), following the manufacturer's guidelines. Bite registration in maximum intercuspation was obtained with a number 7 dental wax (Clássico®, São Paulo, Brazil) and was used to trim the plaster models. The teeth and alveolar ridges in the alginate impressions were filled with type IV plaster (Vigodent®, Rio de Janeiro, Brazil) within one hour after the impression taking, and the base of the models was made from white plaster (Mossoró, Rio de Janeiro, Brazil) (Fig 1).

The volunteers also underwent intraoral scanning of their dentition with the TRIOS Color scanner. Before the start of this study, one examiner was trained in the optimal use of the intraoral scanner. During intraoral scanning, a frame on the computer monitor appears in green (indicating best capture), yellow (regular catch) or red (no image capture). Once the dentist had learned to use the intraoral scanner properly and effectively, the scanning of the dentition of the selected volunteers started.

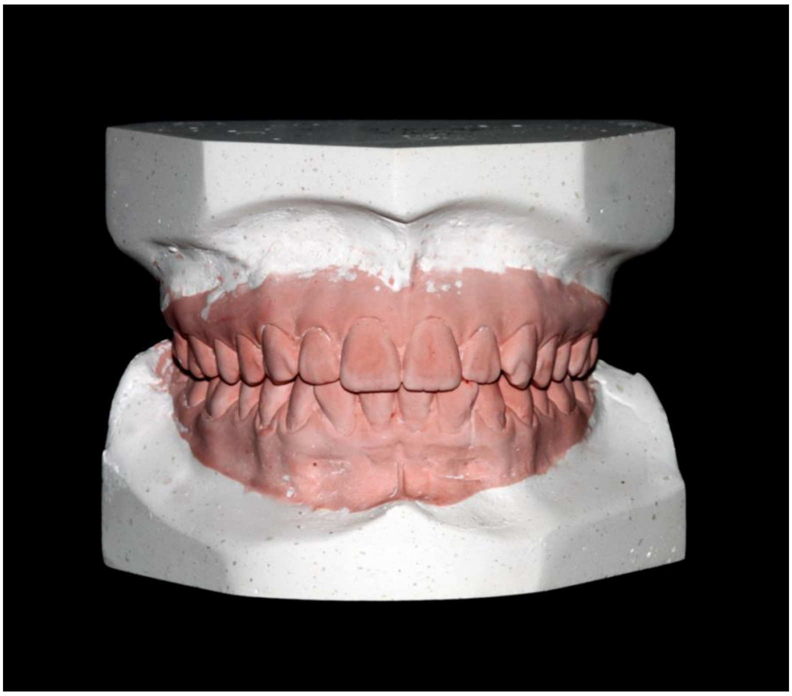

Fig 1. A sample plaster model.

Following the manufacturer’s instructions for the machine, the upper arch was scanned first, followed by the lower arch. After scanning both arches, the volunteer was instructed to occlude in maximum intercuspation to enable scanning of the occlusion on both the right and left sides of the arches. The scanner software then positioned the arches in occlusion. Upon completion of the scanning procedure, the STL files were transferred to Ortho Analyzer software to create digital models (Fig 2). Analyzing the digital model quality revealed that two pair of digital models were inadequate. These two volunteers were asked to return for rescanning but could not comply. Thus, the final study sample included digital models of 28 volunteers.

Fifty-two defined distances (Table 1) were measured on the dental models by two trained and calibrated examiners. Measurements on plaster models were made using a digital caliper with an accuracy of hundredths of millimeters (Starrett, Itu, São Paulo, Brazil) (Fig 3). Measurements on digital models were performed using the Ortho Analyzer software (Fig 4). To investigate the error involved with each method, the measurements of 10 cases of the sample (randomly selected) were repeated after 15 days by the examiners.

Fig 2. Digital model from the intraoral scanner (TRIOS Color).

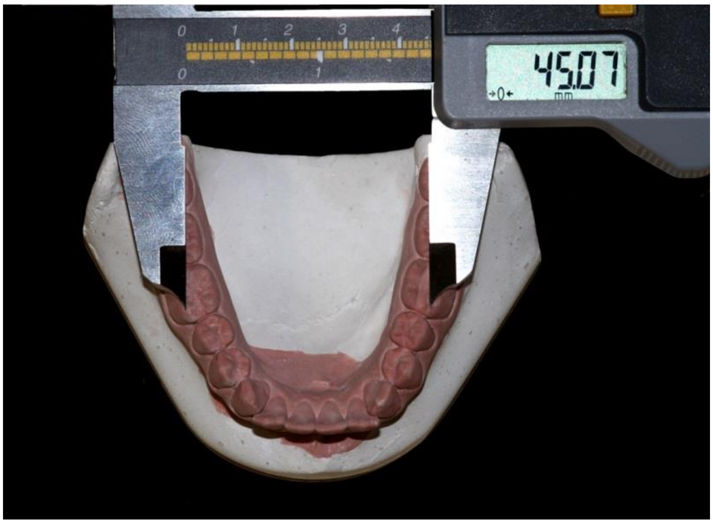

Fig 3. Measuring the lower intermolar distance on a plaster model with a caliper.

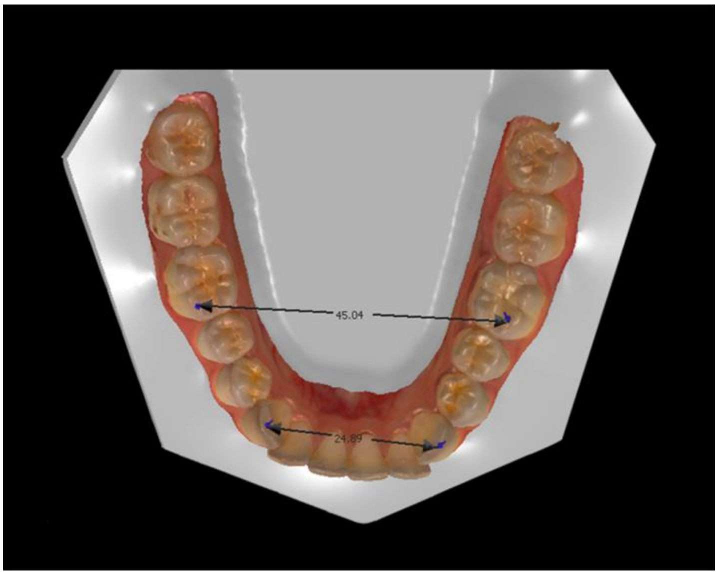

Fig 4. Measuring the lower intermolar and intercanine distances on a digital model with Ortho Analyzer software.

Table 1: Measurement definitions

Measurement	Abbreviation	Definition
Mesiodistal diameter	MDD	Upper and lower mesiodistal diameter from 1st molar to 1st molar (higher mesiodistal diameter of the contact point mesial to distal point of contact, parallel to the occlusal plane)
Sum of upper 6 teeth	Sum upper 6	Diameter sum of 6 anterior upper teeth
Sum of upper 12 teeth	Sum upper 12	Diameter sum of 12 anterior upper teeth
Sum of lower 6 teeth	Sum lower 6	Diameter sum of 6 anterior lower teeth
Sum of lower 12 teeth	Sum lower 12	Diameter sum of 12 anterior lower teeth
Crown Height	CH	Upper and lower crown height of upper and lower 1st molars, 1st premolars, canines and central incisors (from incisal edge or cusp tip to the lower gingival margin from the vestibular axis of each clinical crown - Andrews)
Upper intercanine distance	Upper ICD	Distance between the cusp tip of the upper left canine to cusp tip of the upper right canine
Upper intermolar distance	Upper IMD	Distance between the tip of the mesiobuccal cusp of the upper left 1st molar to the tip of the mesiobuccal cusp of the upper right 1st molar
Lower intercanine distance	Lower ICD	Distance between the cusp tip of the lower left mandibular canine to cusp tip of the lower right canine
Lower intermolar distance	Lower IMD	Distance between the tip of the mesiobuccal cusp of the lower left 1st molar to the tip of the mesiobuccal cusp of the lower right 1st molar
Overjet	Overjet	Distance from the middle of the incisal edge closest to the buccal surface of the upper right maxillary central incisor to the buccal surface of the lower incisor antagonist, parallel to the occlusal plane
Overbite	Overbite	Vertical distance between the marking where the incisal edge of the upper right central incisor overlaps the buccal surface of the lower incisor antagonist until its respective incisal edge
Interarch right sagittal relationship	Right Sag Rel	Distance from the cusp tip of the upper right canine to the marking where the mesiobuccal cusp of the upper right 1st molar occludes to the lower arch
Interarch left sagittal relationship	Left Sag Rel	Distance from the cusp tip of the upper left canine to the marking where the mesiobuccal cusp of the upper left 1st molar occludes to the lower arch

Statistical Analysis

Statistical analyses were performed using the SPSS program, version 20.0 (IBM, Armonk, NY, USA). The measurements on plaster models were defined as a "golden standard" and the outcome of these measurements was compared to the measurements on the digital models from the TRIOS intraoral scanner. For each outcome, a threshold, as described in the literature, was defined to discriminate between a relatively small difference in measurements and a difference that could influence treatment decisions or the accuracy of appliances made on these models (a clinical significant difference). Differences greater than 0.3 mm for the overjet, overbite, and tooth size (tooth diameter and tooth height), and greater than 0.4 mm for transverse and sagittal parameters were considered to be clinically significant (7, 24, 26). For clinical significant differences in the sum of 6 anterior teeth in the upper or lower dental arch, a threshold of 0.75 mm was used. For the sum of 12 teeth in the upper or lower arch, a difference of 1.5 mm was used as a threshold (1, 13). For each outcome and for both observers separately, the chance that a measurement error was bigger than this threshold was calculated. The mean difference between measurements on the digital and plaster models was established (mean dif) and the duplicate measurement error (DME) for digital and plaster models according to each intra-examiner performance was also registered. This measurement error is the sum of the mean difference and a random error, which is a normally distributed variable with a mean value of 0 and a standard deviation of DME. Then, a statistical formula was used:

$P_{\text{bigg error}}$ = P(mean dif + random error) > threshold + P(mean dif + random error) < -threshold

$= P(Z > (\frac{threshold - mean\ dif}{DME})) + P(Z < (\frac{-threshold - mean\ dif}{DME}))$ with Z a normally distributed random variable, with mean of 0 and standard deviation (SD) of 1.

For plaster models this formula was used as well. Obviously, the mean difference was 0, as plaster was defined as the golden standard. But repeated measurements revealed a certain random error. So, for the measurement on plaster the formula above was applied but the "mean dif" was left out, because it is 0. This formula calculated the chance that, due to random error alone, a measurement on plaster shows a significant error. A larger value of p means an increased chance of clinically relevant errors. Arbitrarely, it was considered as a reference that *p*-values larger than 0.3 represent more than 30% of chances to occur measurement differences with a potential clinical impact.

RESULTS

Table 2 shows the outcome of measurements of examiner 1. *P*-value for plaster models presented larger chances of clinically relevant measurement error in the crown height of upper first molars, lower intercanine distance, overbite and left sagittal relationship. For measurements on the digital models, the parameters with *p*-values over 0.3 were: the sum of 6 and 12 lower teeth; crown height of upper first molars, upper central incisors, lower first molars and lower first premolars; upper and lower intercanine distances; lower intermolar distance and left sagittal relationship.

The measurements of examiner 2 are shown in Table 3. These measurements showed a high chance on making a clinically significant measurement error for plaster in the upper and lower intermolar distance and in the left sagittal relationship. Regarding the TRIOS measurements, the following parameters had a high chance on a clinically relevant measurement error: sum of 6 upper teeth, crown height of upper first premolars and upper central incisors and upper and lower intermolar distance. The crown heigh of upper central incisors presented the largest *p*-values by both examiners. The DME of digital models showed larger variability when compared to the DME of the plaster models for examiner 1. This difference in DME between the models was not found for examiner 2.

Table 2: Performance of examiner 1

Parameter	Mean dif plaster and Trios (mm)	DME Trios (mm)	DME Plaster (mm)	Critical value (mm)	*P* value Trios	*P* value Plaster
Sum 6 Upper teeth	-0.3064	0.4686	0.1598	*0.75*	0.1840	0.0000
Sum 12 Upper teeth	-0.3018	0.7239	0.3271	*1.5*	0.0553	0.0000
Sum 6 Lower teeth	-0.7432	0.2750	0.2875	*0.75*	0.4902	0.0091
Sum 12 Lower Teeth	-1.4211	0.5752	0.3831	*1.5*	0.4454	0.0001
CH 16 and 26	-0.2302	0.3154	0.3483	*0.3*	0.4588	0.3890
CH 14 and 24	-0.1098	0.2118	0.1539	*0.3*	0.2110	0.0512
CH 13 and 23	-0.1952	0.0977	0.0988	*0.3*	0.1417	0.0024
CH 11 and 21	-0.3375	0.1132	0.1516	*0.3*	0.6298	0.0479
CH 36 and 46	-0.1573	0.2904	0.1955	*0.3*	0.3693	0.1249
CH 34 and 44	-0.0029	0.2981	0.0842	*0.3*	0.3142	0.0004
CH 33 and 43	0.0246	0.2171	0.1028	*0.3*	0.1698	0.0035
CH 31 and 41	-0.0104	0.1240	0.0948	*0.3*	0.0159	0.0016
Upper ICD	0.4011	0.5877	0.2587	*0.4*	0.5872	0.1220
Lower ICD	-0.3064	0.5194	0.4094	*0.4*	0.5154	0.3286
Upper IMD	0.0382	0.2141	0.2812	*0.4*	0.0659	0.1550
Lower IMD	-0.4239	0.9833	0.2610	*0.4*	0.7108	0.1254
Overjet	0.1079	0.0434	0.1821	*0.3*	0.0000	0.0995
Overbite	0.1818	0.0068	0.3433	*0.3*	0.0000	0.3821
Right Sag Rel	0.1339	0.2467	0.3399	*0.4*	0.1556	0.2392
Left Sag Rel	-0.0468	0.3967	0.4880	*0.4*	0.3167	0.4124

Table 3: Performance of examiner 2

Parameter	Mean dif plaster and Trios (mm)	DME Trios (mm)	DME Plaster (mm)	Critical value (mm)	*P* value Trios	*P* value Plaster
Sum 6 Upper teeth	0.7225	0.3565	0.3214	*0.75*	0.4693	0.0196
Sum 12 Upper teeth	0.6354	0.5503	0.7213	*1.5*	0.0581	0.0376
Sum 6 Lower teeth	-0.4468	0.3753	0.2440	*0.75*	0.2103	0.0021
Sum 12 Lower Teeth	-0.9707	0.5145	0.5387	*1.5*	0.1518	0.0054
CH 16 and 26	-0.1032	0.2096	0.1703	*0.3*	0.2011	0.0782
CH 14 and 24	-0.2621	0.1333	0.1761	*0.3*	0.3882	0.0885
CH 13 and 23	-0.2237	0.1316	0.1239	*0.3*	0.2812	0.0155
CH 11 and 21	-0.3671	0.0690	0.2079	*0.3*	0.8346	0.1490
CH 36 and 46	-0.2250	0.1354	0.1911	*0.3*	0.2899	0.1165
CH 34 and 44	-0.1188	0.1019	0.2850	*0.3*	0.0377	0.2925
CH 33 and 43	-0.0573	0.0924	0.1507	*0.3*	0.0044	0.0465
CH 31 and 41	-0.0793	0.0823	0.0852	*0.3*	0.0037	0.0004
Upper ICD	0.2611	0.2034	0.2665	*0.4*	0.2478	0.1334
Lower ICD	-0.0850	0.2093	0.3098	*0.4*	0.0764	0.1966
Upper IMD	0.0136	0.4031	0.3943	*0.4*	0.3213	0.3104
Lower IMD	0.0354	0.4768	0.4322	*0.4*	0.4028	0.3547
Overjet	-0.0079	0.1911	0.1297	*0.3*	0.1167	0.0207
Overbite	0.1275	0.0244	0.1446	*0.3*	0.0000	0.0380
Right Sag Rel	-0.0757	0.3084	0.1366	*0.4*	0.2079	0.0034
Left Sag Rel	-0.0196	0.2485	0.4676	*0.4*	0.1086	0.3923

DISCUSSION

The use of direct methods to obtain digital models is already widely practiced in orthodontics. For the orthodontist, intraoral scanning represents a tool for fast acquisition of a digital model and an alternative to the indirect impression method. The TRIOS Color intraoral scanner used in this study captures the dentition and the oral cavity without the need to apply powder to the patient’s teeth and mucosa, and the accuracy of the digital models made with this scanner was not studied yet (19). The color display of the dentition and mucosa, permits accurate location of the gingival margin. The images produced by this scanner could replace traditional intraoral imaging with photographs. Furthermore, if an error occurs during scanning, the specific region can easily be rescanned without making a new impression, which can save time.

Studies have shown that measurements made on plaster models may not represent the actual dentition measurements due to possible dimensional changes in impression material and the fabrication process of the plaster model (4, 14). However, plaster models have been used for measurements and appliance fabrication for many years and used in the research literature as a standard. So, for this reason plaster models were also selected as the golden standard in this study. In the literature it has been suggested that intraoral scanning could result in digital models that represents the intraoral situation more accurately because the direct method could result in fewer sources of error (18). It would have been better to compare measurements on a 100% reliable reference model with clearly defined measurement markers as a standard and a copy of this reference model (a plaster model and a scanned model).

The selected reference points for defining various measurements may vary between examiners, even when the points are precisely described. In the literature it has been reported that inadequate reference point localization directly affects measurement reproducibility (3, 4, 6, 10), and therefore measurements on plaster models and digital models are automatically associated with some degree of interpretation inaccuracy. Measurement on digital dental models with dedicated software can reduce the problem of point identification as it is easier on digital models due to the possibility to enlarge and “clip” the digital model (21).

The procedure to scan the dentition, the alveolar bone, and the palate is not difficult. However, inexperienced practitioners will find completion of the first intraoral scans to be more time consuming (13, 18). Therefore, a practitioner’s level of familiarity with the scanning system will substantially influence the time needed to complete the scans (18). Examiners also need training to use specific software to measure the dentition. In the present study, both examiners were trained and calibrated for both measurement methods, but according to the DME values a poor reproducibility was found by both examiners especially in transversal and sagittal parameters and in the sum of tooth diameters. In the literature, it was reported that a high reliability for measurements on digital models can be achieved (13, 16, 24), the cause of the low reproducibility found in this study should be evaluated in a progress study.

The paired *t* test showed that several parameters presented clinically significant differences, especially in transversal and sagittal parameters and in the sum of teeth diameters. In contrast to the results of some other studies (13, 21, 24), the distances measured on digital models were slightly larger compared to the measurements on plaster models. In the sum of upper 6 and 12 teeth, examiner 1 found larger measurement values for digital models, than examiner 2. For the sum of the dimensions of the lower 6 and 12 teeth, both examiners found higher values for the measurements on the digital models. These differences in measurements can be caused by the measuring method (caliper vs. digital measurement) but also by the difference in selection of the measurement point’s position. To reduce the measurement error, both examiners performed the measurements in this study twice. For the difference in dental diameters, none of the measurements presented a *p*-value over 0.3 for examiner 2 for plaster and digital models, but for examiner 1 the *p*-value for the differences in measurements was over 0.3 for lower first molars and lower canine diameters. Clinically relevant errors were reported for measurements on digital models in the sum of 6 and 12 lower teeth by examiner 1 and in the sum of 6 upper teeth by examiner 2.

In relation to the crown height, the upper central incisors and first molars presented the largest clinical errors, possibly because of the structural differences between the plaster and digital models. The digital measuring tool used (direct measurement) available in Ortho Analyzer software could affect the measurement accuracy especially on teeth with a more buccal inclination as upper central incisor.

In this case, other measuring tool as the “digital caliper measurement” could be more accurate to measure the crown height of these teeth. In contrast, most of the crown height of lower teeth presented low values of *p*. In general digital models had higher values in crown height compared to the plaster models.

For measurements of the transversal distances the upper and lower intercanine distances showed larger *p*-values for examiner 1, but not for examiner 2. The upper intermolar distance presented larger values only for examiner 2 and the lower intermolar distance presented bigger chances of clinically significant errors for both examiners. These results were influenced by the high value of DME registered on the digital and plaster models. This can be explained by possible misinterpretations during the selection of reference points (center of the cusp), mainly on teeth with attrition on the reference cusp.

Regarding the interarch relationship parameters (overjet, overbite and sagittal relationship), non-clinical significant differences were found on digital models, with exception of the left sagittal relationship by examiner 1. Measurement of the overbite showed lower *p*-values for digital models for both examiners, and examiner 1 presented a large *p*-value on plaster models. These results suggest that the possibility of clipping the digital models can result in a more accurate measuring method compared to the measuring of the overbite with a caliper on the plaster model.

In the literature, it has been reported, that the occlusion of the digital models made by scanning a plaster model or dental impression and the use of a wax bite registration of the interarch relation, can be inaccurate (13). When intraoral scanners are used, a direct method is used to register the relationship between the upper and lower dentition. In this study a similar occlusion of the digital models from the intraoral scanner compared to plaster models was found, so both methods can be considered reliable.

Several studies evaluated the accuracy of digital models made with intraoral scanners, compared to the accuracy of the dentition on scanned plaster models or scanned dry skulls (16, 18, 20, 21, 23). In other studies, the dentition of volunteers was scanned (13, 18, 23, 24). One study compared the accuracy of digital models from scanning plaster models with those from intraoral scanning of the dentition of patients. In this study, it was reported that the scanned plaster models had a higher accuracy (23). In their publication, the authors mention that the inaccuracy of the intraoral scanning of a patient in this study could have been caused by several factors, including movement of the patient during scanning, limited intraoral space, the presence of moisture and saliva, and an inadequate intraoral scanning technique (23).

In our study, several difficulties with the intraoral scanning procedure were registered. The instructions for the scanner used state that intraoral scanning data will be more accurate when the field to be scanned is dry during the scanning procedure. But maintaining a dry field during scanning of posterior teeth, especially third molars in patients with limited mouth opening was sometimes difficult. It was sometimes also difficult to scan the bottom of the oral vestibule. This problem was related to the dimensions of the scanning tip, the interference between the tip and the patient's coronoid process, and moisture control. According to a study of Grunheid et al. (18), most patients mentioned that the scanning of the buccal surfaces of the maxillary second and third molars was uncomfortable. As scanning technology continues to evolve, the scanning process can be faster and the design of a thinner scanning tip may improve comfort and this will increase patient acceptance of the scanning procedure. As the accuracy of TRIOS Color intraoral scanner compared to plaster models was clinically acceptable for most of the measurements, this scanner can be used as an alternative for the traditional impression technique. However to improve the reproducibility of the measuring method, the parameters should be better standardized on both plaster and digital models (19).

CONCLUSION

The results show that some parameters presented a high chance to register a clinically significant measurement error. The measurement of the crown height of upper central incisors in digital models showed the largest clinically significant errors for both examiners. The differences between the measurements can be caused by actual differences on the models or can be caused by the measurement method. The reproducibility of the measurements was different between the examiners for some parameters. Despite the presence of some clinically significant chances of error, it can be assumed that digital models from TRIOS Color intraoral scanner can be used to replace the plaster models for clinical use in orthodontics.

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3.3 - Artigo 3 – A ser submetido para o American Journal of Orthodontics and Dentofacial Orthopedics.

Title: Comparison of two different types of plaster model scanners and two different measurement software.

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Key words: Digital model, dental measurement, scanning, orthodontics

ABSTRACT

Introduction: The use of digital models in orthodontics has increased. Digital models can be fabricated indirectly by scanning a plaster model or impressions of the dentition, or directly by the process of intraoral scanning. Because of the diversity of existing methods, the aim of this study is to compare the accuracy and reliability of measurements on digital models made with two types of plaster cast scanners (a laser scanner and a CT scanner) measuring with two different software. **Methods:** Thirty plaster models were scanned with a 3Shape dental model laser scanner and with a Flash CT scanner. The measurements on both digital models were performed by two examiners, with Ortho Analyzer (3Shape) and Digimodel (OrthoProof) software. Fifty two distances were measured, including tooth diameter and height, overjet, overbite, intercanine and intermolar distances, and the sagittal relationship. The paired *t* test was used to assess intra-examiner error, interexaminer error, the comparison between measurements on the plaster models (with calipers) and digital models (with measuring software), and on each digital model. Measurement reliability was evaluated using the Pearson correlation test. **Results:** Statistically significant differences between measurements on the plaster and digital models were found; however, these discrepancies were considered clinically insignificant. Measurements on both plaster casts and digital models made with the two different scanning methods showed high Pearson correlation values. The software used for measuring did not influence the accuracy of measurements. **Conclusions:** Digital models created by 3Shape laser scanner or the Flashdigital model CT scanner are accurate and reliable and can replace conventional plaster models. It is possible to measure each digital model with the Ortho Analyzer or Digimodel software without compromising the measurements accuracy.

INTRODUCTION

Dental study models in plaster have been an essential part of patient records in orthodontics. They are a valuable tool for diagnosis and treatment planning and can also provide a dynamic assessment of the treatment progress of clinical cases. However, plaster models present some problems such as storage, breakage and loss.[1,2] The use of digital models in orthodontics has increased because of their advantages and will probably replace the traditional plaster models. In the last two decades, the methods, techniques and software used for 3D scanning systems for plaster models and dental impressions have been continuously improved. Plaster models can now be scanned by different scanning methods, such as laser scanning, structured light scanning or computer tomographic (CT) scanning. In laser scanning systems, receivers capture the laser beams that reach the object. These systems typically operate with three, four or more different laser beams. The scanning software can record the time between the emission of the laser beam and the reflection of the laser beams to capture the object such as a dental impression or plaster model, based on triangulation. Computer Tomographic (CT) scanners provide information about both superficial and deep structures of the plaster models, dental impressions and wax bite registrations. The disadvantages of CT scanning of plaster models include absence of color value and radiation exposure.[3]

Some companies such as 3Shape® (Copenhagen, Denmark); GeoDigm Corporation Inc.® (Falcon Heights, Minnesota, USA); Ortho Cast® (High Bridge, New Jersey, USA); and XCADCAM Tecnologia® (São Paulo, São Paulo, Brazil) use laser scanners to scan plaster models and dental impressions. Other companies like OrthoProof® (Nieuwegein, The Netherlands), OraMetrix® (Richardson, Texas, USA) and Align Technology Inc.® (San Jose, California, USA) use CT scanners. The accuracy of digital dental models acquired by laser scanning of plaster models had already been evaluated.[1,4-22] The accuracy of digital models made by scanning plaster casts with structured light and CT scanners were not studied intensively.[4,23,24] CT scanners are more used to scan impressions of alginate or polivinilsiloxane (PVS) materials,[2,25,26] and some studies evaluated the use of structured light scanners for soft tissue analyses.[3] Data obtained by different types of 3D scanning systems origin clouds of points, which must then be triangulated to be converted into "renderable" surfaces. These areas need to be closed so that the models can be printed on 3D printers.

The orthodontist who uses digital models for the diagnosis and treatment plan needs to use specific software to perform measurements, to execute the dental analyses and to make virtual setups. There are several software available for this purpose, such as: E-models® (GeoDigm Corporation Inc.); Ortho Analyzer® (3Shape); SureSmile® (OraMetrix), Maestro3D® (AGE Solutions®, Pisa, Italy) NemoCast® (Nemotec®, Madrid, Spain) and Digimodel (OrthoProof). Although most software present similar tools, training is needed to master each program.[27] In general, the software can show the digital model with different plane views; this model can be enlarged using the zoom function and the images can be segmented, using clipping functions. Most software for analyzing digital models are able to map occlusal contacts and can be used to make measurements from point to point, point to plane, or from plane to plane. However, not all systems can automatically provide the peer assessment rating index (PAR index) or the index of the American Board of Orthodontics (ABO) analysis.

Several types of scanners with different scanning methods combined with a diversity of digital models manipulation's software are available and used in orthodontics. Therefore, research is needed to reveal the accuracy and reliability of both the digital models as the model measurement's software. As the files of the scanner (stereolitographic (STL) files) and the files of the CT scanner (DICOM files) can be used with different software, it should be tested if the software used for evaluation, treatment planning, appliance design and fabrication can be used for both the STL files and DICOM files of the digital models. In this study, the accuracy and reliability of measurements were tested on digital models made from plaster models scanned with two different scanners: a laser scanner R700® (3Shape) and a Flash CT scanner® (model FCT-1600, Hytec Inc.®, Los Alamos, NM, USA) at 160 kV with a voxel resolution of 0.05 mm. Each pair of digital models was measured with two different software: Ortho Analyzer (3Shape) and Digimodel (OrthoProof) to evaluate the influence of the measuring software on the accuracy of digital models.

MATERIALS AND METHODS

Plaster models of 10 individuals were used to determine the power for this study. The formula described by Pandis,[28] assuming a 90% power test, α of 0.05, to detect a difference of 1mm with a standard deviation of 1.16mm was used. The sample size calculation revealed the need for a sample of at least 29 plaster casts. Ethical approval for the study was gained (Reference number: 221.664, 01/02/2013).

Alginate impressions were made from a sample of students at the Orthodontic Department of Federal Fluminense University, Brazil. Inclusion criteria for the selected patients were: fully erupted permanent dentition (including all upper and lower first permanent molars). Dentitions showing dental anomalies in size and shape, presence of severe gingival recessions, dental crown abrasions, attritions and erosions or with fixed orthodontic retention, were excluded. The sample consisted of 30 volunteers. The age of the volunteers at the time of impression taking was between 21 and 39 years, with an average of 27 years and 9 months.

Alginate impressions of the upper and lower arch were made (Hydrogum® Zhermack®, Badia Polesine, Rovigo, Italy), following the manufacturer's guidelines. The bite registration was made with number 7 dental wax (Clássico®, São Paulo, Brazil). This bite registration was used for trimming of the base of the plaster casts. According the manufacture guidelines, the impressions were kept in a humidified storage during 20 minutes to finish the alginate pray, and then the plaster was poured. The impression of the teeth and the alveolar ridge were poured with type IV plaster (Vigodent®, Rio de Janeiro, Brazil) and the base of the plaster model was poured with white plaster (Mossoró®, Rio de Janeiro, Brazil). These plaster models were considered as the "golden standard" for measurements performed in this study.

Each set of plaster models was scanned with two types of scanners, the R700 laser scanner (3Shape) and the Flash CT scanner (OrthoProof). In 3Shape scanner, the upper and lower models were scanned separately. Then, the plaster models were scanned in occlusion to obtain the interarch relationship. Sagittal, transverse and vertical adjustments were made to create the virtual upper and lower bases of the digital model according to the instructions of the 3Shape software. In the CT scanner, the upper and lower models and the bite registration were scanned at the same time, and the occlusion was adjusted by the technician with the Digimodel software using the scanned wax bite registration as a reference.

For analysis, 52 parameters with clinical relevance for orthodontics were defined (Table I). Two trained and calibrated examiners performed the measurements on the plaster and digital models. For measurements on plaster models, a digital caliper with an accuracy of hundredths of millimeters (Tesa SA®, Renens, Switzerland) was used. The measurements on all digital models were made with the Ortho Analyzer software (version 1.5.1.7, updated in May, 13, 2015) and Digimodel software (version 3.25.0, updated in Mar, 6, 2015). The digital models scanned in OrthoProof scanner was converted to stl files to be opened in Ortho Analyzer software and the digital models scanned in 3Shape scanner was also converted in opm files to be opened in Digimodel software. Therefore, four different measurements on the two digital models were made: 3Shape models measured with Ortho Analyzer software (3Shape models OA), 3Shape models measured with Digimodel software (3Shape models DM), OrthoProof models measured with Ortho Analyzer software (OrthoProof models OA) and OrthoProof models measured with Digimodel software (OrthoProof models DM) (Fig 1) . Examiner 1 performed all the measurements and examiner 2 performed the measurements of 27 selected parameters to evaluate the reliability of the method.

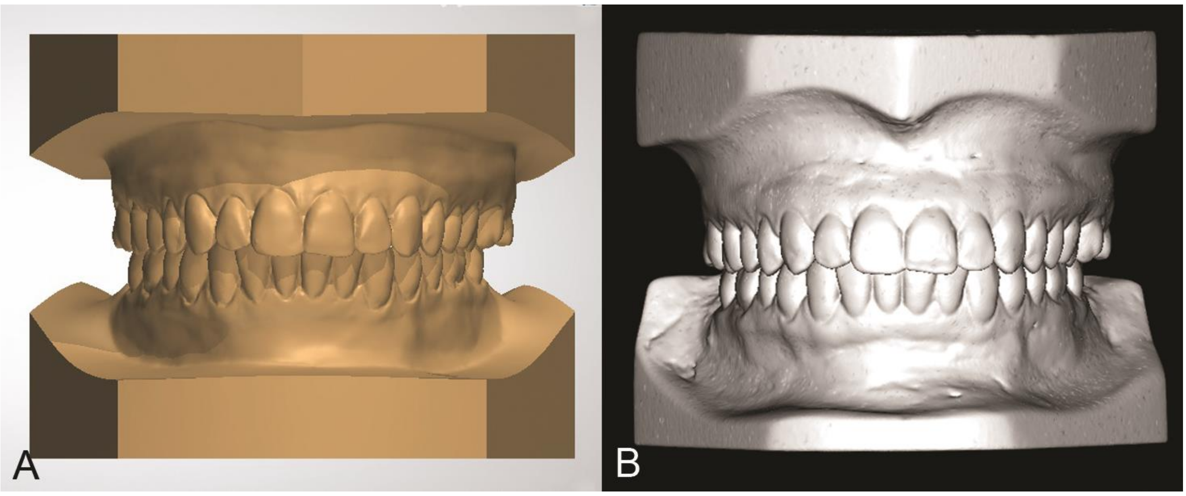

Fig 1. A, 3Shape model in Ortho Analyzer software; **B**, OrthoProof model in Digimodel software.

Table I: Measurement definitions

Measurement	Abbreviation	Definition
Mesiodistal diameter	MDD	Upper and lower mesiodistal diameter from 1st molar to 1st molar (higher mesiodistal diameter of the contact point mesial to distal point of contact, parallel to the occlusal plane)
Sum of upper 6 teeth	Sum upper 6	Diameter sum of 6 anterior upper teeth
Sum of upper 12 teeth	Sum upper 12	Diameter sum of 12 anterior upper teeth
Sum of lower 6 teeth	Sum lower 6	Diameter sum of 6 anterior lower teeth
Sum of lower 12 teeth	Sum lower 12	Diameter sum of 12 anterior lower teeth
Crown Height	CH	Upper and lower crown height of upper and lower 1st molars, 1st premolars, canines and central incisors (from incisal edge or cusp tip to the lower gingival margin from the vestibular axis of each clinical crown - Andrews)
Upper intercanine distance	Upper ICD	Distance between the cusp tip of the upper left canine to cusp tip of the upper right canine
Upper intermolar distance	Upper IMD	Distance between the tip of the mesiobuccal cusp of the upper left 1st molar to the tip of the mesiobuccal cusp of the upper right 1st molar
Lower intercanine distance	Lower ICD	Distance between the cusp tip of the lower left mandibular canine to cusp tip of the lower right canine
Lower intermolar distance	Lower IMD	Distance between the tip of the mesiobuccal cusp of the lower left 1st molar to the tip of the mesiobuccal cusp of the lower right 1st molar
Overjet	Overjet	Distance from the middle of the incisal edge closest to the buccal surface of the upper right maxillary central incisor to the buccal surface of the lower incisor antagonist, parallel to the occlusal plane
Overbite	Overbite	Vertical distance between the marking where the incisal edge of the upper right central incisor overlaps the buccal surface of the lower incisor antagonist until its respective incisal edge
Interarch right sagittal relationship	Right Sag Rel	Distance from the cusp tip of the upper right canine to the marking where the mesiobuccal cusp of the upper right 1st molar occludes to the lower arch
Interarch left sagittal relationship	Left Sag Rel	Distance from the cusp tip of the upper left canine to the marking where the mesiobuccal cusp of the upper left 1st molar occludes to the lower arch

Statistical analysis

Statistical analyses was performed with the SPSS program, version 20.0 (IBM, Armonk, NY, USA). To calculate the intra examiner performance, measurements were repeated by examiner 1 after 15 days on one third of the sample, randomly selected. The difference of both intra and inter observer performance as well as the comparison of measurements made on different types of dental models, was quantified by the paired *t* test. The Pearson correlation coefficient was calculated to establish the examiner reliability. *P*-values < 0.05 were considered to be statistically significant.

RESULTS

Examiners 1 and 2 presented an excellent interexaminer reliability with few statistically significant differences in the parameters selected according the paired *t* test. The highest difference was in the right sagittal relationship parameter, especially in OrthoProof models measured with OA and DM software. According to the Pearson correlation, the mean of all parameters was 0.958 for plaster models, 0.928 for 3Shape models measured with OA, 0.946 for OrthoProof models measured with OA, 0.969 for 3Shape models measured with DM and 0.955 for OrthoProof models measured with DM (Table II).

The intra-examiner reliability for examiner 1, who measured all the distances, was evaluated. The mean differences for all measurement parameters was 0.072mm for the plaster model, and on the parameters measured with the Ortho Analyzer software was -0.066mm for 3Shape models and -0.049mm for OrthoProof models. The intra-examiner reliability for the measurements with Digimodel software was -0.014mm for 3Shape models and 0.021mm for OrthoProof models. The highest intra-examiner differences were found in the sum of 12 upper teeth for plaster models (0.870mm), for OrthoProof models measured with OA (-0.527mm) and for OrthoProof models measured with DM (0.815mm). The highest intra-examiner difference measured found on 3Shape models measured with OA was 0.832mm for the sum of 12 lower teeth, and in 3Shape models measured with DM was 0.423mm for the sum of 6 upper teeth.

Measurements on plaster models were compared with measurements on each digital model. Some parameters showed statistically significant differences, but few measurements presented clinically significant differences (Table III). In this study, the same criteria for clinical statistical differences as described in the literature were used. Differences more than 0.3mm for the overjet, overbite, and tooth size (tooth diameter and tooth height), and more than 0.4mm for transversal and sagittal parameters were considered to be clinically significant.[12,29] For differences in the sum of 6 anterior teeth in the upper or lower dental arch, a threshold of 0.75mm was used. For the sum of 12 teeth in the upper or lower arch, a difference of 1.5mm was used to register clinically significant differences.[30]

None of the measurements of the mesiodistal diameter measured on a digital model presented a clinically significance difference compared to the measurements on plaster models. In general, digital models presented diameters with higher values compared to the plaster models, with exception of 3Shape models measured with DM, which presented lower values of the sum of upper and lower diameters of 6 and 12 teeth. The OrthoProof models measured with DM also presented higher values in the sum of lower teeth diameter, compared to the plaster models. The differences in crown height between the models also showed some statistically significant differences with no clinically significant differences for OrthoProof models measured with DM, one for 3Shape models measured with OA and 3Shape models measured with DM, and two clinically significant differences in OrthoProof models measured with DM. For transversal parameters, only the upper intercanine distance (in all digital models) and lower intermolar distance (in 3Shape models measured with OA and OrthoProof models measured with OA), presented statistically significant differences, compared to the measurements on plaster models, but only 3Shape models measured with DM and OrthoProof models measured with DM presented clinically significant differences in the upper intercanine distance. The measurements of the overbite presented more differences between digital models and plaster models compared to overjet. The 3Shape models measured with DM presented the highest difference in sagittal relationship (Table III).

In Table IV the differences in measurements between the two digital models with two different software are presented. The comparison showed no clinically significant differences between 3Shape models and OrthoProof models measured with Ortho Analyzer software. In relation to the measurements with Digimodel software, a clinically significant difference in the sum of 6 upper teeth was found. The same digital model measured with the two different software showed 3 clinically significant differences in 3Shape models and OrthoProof models. In 3Shape models these differences were in the sum of 6 upper teeth and the crown height of teeth 34 and 36, while in the OrthoProof models clinical significant difference was found in the sum of 6 and 12 lower teeth and the crown height of tooth 24. The measurements of transversal and sagittal distances showed some statistically significant differences but none of these differences were clinically significant. For the measurements of the overjet and overbite no statistically significant differences were found (Table IV).

Table II: Measurement comparison between examiners according to the paired *t* test

Parameter	Plaster model				3Shape OA				OrthoProof OA				3Shape DM				OrthoProof DM			
	Reliability	Mean difference	S error	*p*	Reliability	Mean difference	S error	*p*	Reliability	Mean difference	S error	*p*	Reliability	Mean difference	S error	*p*	Reliability	Mean difference	S error	*p*
MDD 16	0.964	-0.099	0.217	0.098	0.657	0.060	0.478	0.634	0.897	0.129	0.251	0.065	0.896	-0.020	0.299	0.799	0.911	-0.020	0.251	0.763
MDD 15	0.947	-0.115	0.171	**0.021**	0.928	-0.069	0.197	0.194	0.977	0.101	0.123	**0.007**	0.972	0.083	0.125	**0.022**	0.892	0.107	0.231	0.096
MDD 14	0.966	-0.104	0.119	**0.004**	0.940	-0.037	0.194	0.477	0.931	0.007	0.189	0.882	0.975	0.043	0.112	0.157	0.960	0.117	0.138	**0.005**
MDD 13	0.949	0.007	0.160	0.861	0.869	0.147	0.309	0.086	0.878	0.121	0.297	0.138	0.967	0.040	0.143	0.296	0.950	0.147	0.192	**0.010**
MDD 12	0.980	-0.021	0.124	0.528	0.951	0.004	0.192	0.937	0.837	-0.051	0.348	0.582	0.915	-0.121	0.256	0.088	0.948	-0.057	0.187	0.254
MDD 11	0.984	-0.016	0.090	0.501	0.935	-0.022	0.224	0.710	0.943	-0.054	0.168	0.233	0.948	-0.120	0.168	**0.015**	0.951	-0.173	0.187	**0.003**
MDD 41	0.857	-0.051	0.188	0.307	0.782	0.034	0.272	0.636	0.916	-0.024	0.173	0.599	0.943	-0.088	0.120	**0.013**	0.894	-0.004	0.161	0.925
MDD 42	0.959	-0.015	0.116	0.631	0.863	-0.080	0.245	0.226	0.930	0.063	0.191	0.221	0.974	0.026	0.125	0.434	0.956	0.003	0.155	0.948
MDD 43	0.902	-0.021	0.214	0.706	0.951	-0.051	0.193	0.326	0.862	0.097	0.285	0.208	0.970	-0.011	0.144	0.764	0.899	0.055	0.276	0.456
MDD 44	0.965	-0.075	0.109	**0.018**	0.926	-0.075	0.171	0.113	0.933	-0.031	0.184	0.528	0.960	-0.118	0.127	**0.003**	0.886	0.183	0.201	**0.003**
MDD 45	0.913	-0.093	0.163	**0.045**	0.749	-0.143	0.324	0.110	0.851	0.113	0.267	0.124	0.951	0.005	0.149	0.905	0.923	0.165	0.168	**0.002**
MDD 46	0.960	-0.079	0.204	0.154	0.949	0.014	0.228	0.815	0.939	0.161	0.240	**0.021**	0.960	0.005	0.207	0.922	0.982	0.169	0.132	**0.000**
CH 16	0.942	-0.185	0.331	**0.048**	0.986	0.119	0.172	**0.018**	0.939	0.233	0.298	**0.009**	0.983	0.068	0.170	0.144	0.950	0.094	0.268	0.196
CH 14	0.967	0.014	0.246	0.829	0.988	0.135	0.167	**0.008**	0.979	0.268	0.226	**0.000**	0.990	0.091	0.151	**0.034**	0.984	0.033	0.174	0.469
CH 13	0.976	0.003	0.186	0.956	0.988	0.127	0.135	**0.003**	0.987	**0.312**	0.147	**0.000**	0.988	0.104	0.135	**0.010**	0.988	0.161	0.129	**0.000**
CH 11	0.993	-0.057	0.152	0.166	0.997	0.011	0.091	0.636	0.989	0.198	0.169	**0.000**	0.991	0.018	0.152	0.654	0.993	-0.061	0.144	0.125
CH 41	0.980	0.028	0.179	0.555	0.985	0.017	0.166	0.691	0.988	0.129	0.134	**0.002**	0.981	-0.034	0.159	0.420	0.973	0.063	0.212	0.272
CH 43	0.989	-0.047	0.189	0.349	0.986	0.035	0.201	0.516	0.992	0.191	0.170	**0.001**	0.984	0.023	0.198	0.655	0.993	0.137	0.140	**0.002**
CH 44	0.978	0.005	0.208	0.922	0.945	0.172	0.325	0.059	0.983	0.297	0.185	**0.000**	0.988	0.068	0.159	0.120	0.979	0.059	0.210	0.292
CH 46	0.970	0.089	0.193	0.097	0.938	0.269	0.296	**0.003**	0.971	0.256	0.179	**0.000**	0.983	0.208	0.177	**0.000**	0.956	-0.015	0.232	0.801
Upper ICD	0.972	0.025	0.585	0.869	0.982	-0.212	0.439	0.083	0.971	0.077	0.539	0.587	0.989	0.071	0.413	0.514	0.943	0.101	0.707	0.588
Lower ICD	0.953	0.125	0.655	0.471	0.976	0.229	0.534	0.118	0.963	0.266	0.545	0.079	0.979	0.063	0.449	0.597	0.995	0.137	0.264	0.065
Upper IMD	0.996	0.074	0.331	0.401	0.981	0.210	0.675	0.248	0.995	0.177	0.350	0.070	0.998	0.173	0.247	**0.017**	0.994	0.299	0.357	**0.006**
Lower IMD	0.969	0.126	0.699	0.496	0.992	0.342	0.313	**0.001**	0.988	0.268	0.410	**0.024**	0.990	0.278	0.370	**0.011**	0.986	0.129	0.480	0.317
Overjet	0.958	-0.051	0.272	0.483	0.856	-0.216	0.438	0.077	0.943	0.001	0.251	0.992	0.930	-0.043	0.258	0.526	0.953	-0.140	0.299	0.091
Overbite	0.937	-0.184	0.455	0.140	0.985	0.037	0.176	0.425	0.988	0.040	0.176	0.393	0.997	-0.003	0.078	0.870	0.971	0.093	0.250	0.170
Right Sag Rel	0.947	0.355	0.708	0.072	0.973	0.359	0.499	**0.015**	0.972	**0.675**	0.490	**0.000**	0.967	0.386	0.530	**0.014**	0.980	**0.471**	0.473	**0.002**

3Shape OA: 3shape models measured in Ortho Analyzer software; 3Shape DM: 3Shape models measured in Digimodel software. OrthoProof OA: OrthoProof models measured in Ortho Analyzer software; OrthoProof DM: OrthoProof models measured in Digimodel software.

Table III: Measurement comparison between plaster and digital models by examiner 1 according to the paired *t* test

Parameter	Plaster model x 3Shape OA				Plaster model x OrthoProof OA				Plaster model x 3Shape DM				Plaster model x OrthoProof DM			
	Reliability	Mean difference (mm)	S error	*p*	Reliability	Mean difference (mm)	S error	*p*	Reliability	Mean difference (mm)	S error	*p*	Reliability	Mean difference (mm)	S error	*p*
Sum 6 Upper teeth	0.973	0.279	0.643	**0.024**	0.976	-0.003	0.556	0.979	0.988	**1.130**	0.394	**0.000**	0.986	0.330	0.449	**0.000**
Sum 12 Upper teeth	0.983	-0.151	0.947	0.390	0.988	-0.859	0.760	**0.000**	0.991	0.769	0.663	**0.000**	0.991	-0.312	0.695	**0.020**
Sum 6 Lower teeth	0.959	-0.085	0.699	0.509	0.965	-0.562	0.598	**0.000**	0.975	0.558	0.488	**0.000**	0.945	0.252	0.722	0.066
Sum 12 Lower Teeth	0.960	-0.224	1.301	0.354	0.984	-1.048	0.815	**0.000**	0.975	0.589	0.993	**0.003**	0.969	0.509	1.068	**0.014**
CH 16	0.933	**-0.359**	0.330	**0.000**	0.922	**-0.308**	0.350	**0.000**	0.958	-0.268	0.267	**0.000**	0.859	-0.156	0.481	0.086
CH 14	0.953	-0.137	0.292	**0.016**	0.945	-0.222	0.311	**0.001**	0.955	-0.226	0.288	**0.000**	0.946	-0.164	0.304	**0.006**
CH 13	0.956	-0.093	0.257	0.056	0.978	-0.197	0.177	**0.000**	0.972	-0.110	0.202	**0.006**	0.915	-0.164	0.346	**0.015**
CH 11	0.976	-0.142	0.202	**0.001**	0.981	-0.274	0.182	**0.000**	0.979	-0.170	0.208	**0.000**	0.982	-0.057	0.179	0.090
CH 21	0.970	-0.045	0.233	0.299	0.980	-0.206	0.192	**0.000**	0.975	-0.098	0.213	**0.018**	0.966	0.027	0.247	0.549
CH 23	0.972	-0.069	0.211	0.083	0.973	**-0.304**	0.208	**0.000**	0.975	-0.070	0.205	0.071	0.932	-0.031	0.327	0.612
CH 24	0.974	-0.119	0.236	**0.010**	0.978	-0.259	0.210	**0.000**	0.970	-0.097	0.252	**0.043**	0.936	0.097	0.362	0.153
CH 26	0.963	0.211	0.288	**0.000**	0.914	0.110	0.366	**0.111**	0.916	0.086	0.355	0.196	0.910	0.260	0.370	**0.001**
CH 36	0.921	-0.097	0.267	0.056	0.904	-0.258	0.293	**0.000**	0.928	**-0.403**	0.262	**0.000**	0.791	-0.260	0.422	**0.002**
CH 34	0.880	0.087	0.501	0.350	0.937	-0.171	0.319	**0.007**	0.925	-0.248	0.347	**0.001**	0.890	-0.194	0.416	**0.016**
CH 33	0.986	0.046	0.212	0.248	0.980	-0.149	0.245	**0.002**	0.983	-0.207	0.229	**0.000**	0.923	-0.200	0.476	**0.028**
CH 31	0.966	0.030	0.220	0.465	0.969	-0.057	0.207	0.145	0.961	-0.133	0.229	**0.004**	0.921	-0.119	0.330	0.058
CH 41	0.969	-0.018	0.192	0.618	0.931	0.041	0.283	0.438	0.950	-0.085	0.242	0.065	0.948	-0.093	0.247	**0.047**
CH 43	0.980	-0.069	0.215	0.090	0.966	-0.138	0.279	**0.011**	0.966	-0.143	0.278	**0.009**	0.871	-0.254	0.528	**0.013**
CH 44	0.978	0.078	0.199	**0.040**	0.970	-0.136	0.223	**0.002**	0.971	-0.060	0.226	0.156	0.947	-0.077	0.290	0.155
CH 46	0.907	-0.017	0.331	0.780	0.930	-0.062	0.283	0.240	0.961	-0.257	0.212	**0.000**	0.932	-0.061	0.278	0.239
Upper ICD	0.975	0.327	0.448	**0.000**	0.972	0.285	0.475	**0.003**	0.979	**0.437**	0.410	**0.000**	0.975	**0.402**	0.442	**0.000**
Lower ICD	0.969	-0.144	0.494	0.121	0.953	-0.152	0.525	0.124	0.968	0.024	0.446	0.767	0.968	-0.020	0.476	0.820
Upper IMD	0.991	-0.018	0.431	0.817	0.987	0.113	0.514	0.237	0.986	-0.046	0.539	0.646	0.973	0.118	0.740	0.390
Lower IMD	0.982	-0.281	0.482	**0.003**	0.983	-0.283	0.484	**0.003**	0.982	0.035	0.508	0.711	0.970	-0.016	0.667	0.896
Overjet	0.954	0.110	0.283	**0.042**	0.902	0.107	0.413	0.168	0.937	0.084	0.331	0.174	0.857	0.039	0.480	0.660
Overbite	0.948	**0.315**	0.283	**0.000**	0.911	0.265	0.379	**0.001**	0.936	**0.303**	0.321	**0.000**	0.856	0.210	0.539	**0.042**
Right Sag Rel	0.930	-0.121	0.654	0.321	0.938	-0.243	0.596	**0.034**	0.905	**-0.423**	0.723	**0.003**	0.808	-0.260	1.084	0.199
Left Sag Rel	0.926	-0.134	0.684	0.293	0.960	-0.236	0.484	**0.012**	0.970	-0.239	0.415	**0.004**	0.935	-0.225	0.647	0.067

3Shape OA: 3shape models measured in Ortho Analyzer software; 3Shape DM: 3Shape models measured in Digimodel software. OrthoProof OA: OrthoProof models measured in Ortho Analyzer software; OrthoProof DM: OrthoProof models measured in Digimodel software.

Table IV: Measurement comparison between digital models by examiner 1 according to the paired *t* test

Parameter	3Shape OA x OrthoProof OA				3Shape DM x OrthoProof DM				3Shape OA x 3Shape DM				OrthoProof DM x OrthoProof OA			
	Reliability	Mean difference (mm)	S error	*p*	Reliability	Mean difference (mm)	S error	*p*	Reliability	Mean difference (mm)	S error	*p*	Reliability	Mean difference (mm)	S error	*p*
Sum 6 Upper teeth	0.956	-0.282	0.813	0.068	0.984	**-0.801**	0.480	**0.000**	0.977	**0.851**	0.599	**0.000**	0.975	-0.332	0.594	**0.005**
Sum 12 Upper teeth	0.977	-0.708	1.077	**0.001**	0.988	-1.081	0.795	**0.000**	0.985	0.920	0.882	**0.000**	0.991	-0.548	0.702	**0.000**
Sum 6 Lower teeth	0.957	-0.476	0.685	**0.001**	0.949	-0.307	0.698	**0.023**	0.970	0.644	0.586	**0.000**	0.965	**-0.813**	0.591	**0.000**
Sum 12 Lower Teeth	0.959	-0.824	1.307	**0.002**	0.970	-0.080	1.074	0.686	0.975	0.813	1.030	**0.000**	0.982	**-1.557**	0.851	**0.000**
CH 16	0.942	0.051	0.310	0.379	0.881	0.112	0.454	0.187	0.942	0.091	0.313	0.123	0.890	-0.152	0.433	0.064
CH 14	0.971	-0.085	0.230	0.052	0.948	0.062	0.309	0.279	0.982	-0.089	0.183	**0.013**	0.940	-0.058	0.325	0.334
CH 13	0.969	-0.104	0.216	**0.013**	0.917	-0.055	0.344	0.391	0.981	-0.016	0.171	0.605	0.900	-0.033	0.379	0.637
CH 11	0.971	-0.132	0.224	**0.003**	0.971	0.113	0.247	**0.018**	0.980	-0.028	0.179	0.399	0.982	-0.217	0.180	**0.000**
CH 21	0.975	-0.161	0.212	**0.000**	0.979	0.125	0.191	**0.001**	0.989	-0.053	0.145	0.056	0.978	-0.233	0.199	**0.000**
CH 23	0.957	-0.235	0.263	**0.000**	0.920	0.040	0.336	0.523	0.979	-0.001	0.187	0.977	0.939	-0.274	0.308	**0.000**
CH 24	0.970	-0.140	0.254	**0.005**	0.945	0.194	0.308	**0.002**	0.965	0.021	0.283	0.682	0.949	**-0.356**	0.315	**0.000**
CH 26	0.928	-0.101	0.381	0.156	0.868	0.174	0.400	**0.024**	0.898	-0.126	0.459	0.145	0.871	-0.150	0.436	0.070
CH 36	0.936	-0.161	0.229	**0.001**	0.791	0.143	0.376	**0.046**	0.942	**-0.305**	0.222	**0.000**	0.832	0.001	0.355	0.984
CH 34	0.926	-0.258	0.413	**0.002**	0.914	0.054	0.353	0.408	0.940	**-0.335**	0.383	**0.000**	0.947	0.023	0.281	0.657
CH 33	0.966	-0.195	0.328	**0.003**	0.921	0.007	0.456	0.934	0.986	-0.253	0.224	**0.000**	0.941	0.051	0.417	0.509
CH 31	0.964	-0.086	0.222	**0.042**	0.932	0.014	0.291	0.799	0.982	-0.162	0.160	**0.000**	0.938	0.062	0.291	0.249
CH 41	0.909	0.058	0.327	0.337	0.974	-0.009	0.162	0.771	0.968	-0.067	0.201	0.078	0.894	0.134	0.336	**0.037**
CH 43	0.972	-0.070	0.250	0.138	0.847	-0.111	0.555	0.281	0.982	-0.074	0.205	0.056	0.870	0.116	0.528	0.238
CH 44	0.965	-0.214	0.248	**0.000**	0.963	-0.017	0.257	0.715	0.953	-0.138	0.292	**0.015**	0.964	-0.059	0.243	0.194
CH 46	0.861	-0.045	0.403	0.545	0.890	0.196	0.345	**0.004**	0.895	-0.240	0.351	**0.001**	0.864	-0.001	0.380	0.989
Upper ICD	0.971	-0.042	0.483	0.637	0.960	-0.035	0.552	0.731	0.977	0.110	0.424	0.165	0.974	-0.117	0.453	0.167
Lower ICD	0.942	-0.008	0.655	0.947	0.958	-0.044	0.538	0.655	0.964	0.168	0.517	0.085	0.955	-0.132	0.561	0.207
Upper IMD	0.986	0.132	0.522	0.178	0.961	0.164	0.892	0.323	0.984	-0.027	0.565	0.793	0.962	-0.005	0.871	0.977
Lower IMD	0.982	-0.002	0.496	0.983	0.985	-0.051	0.466	0.556	0.987	0.315	0.432	**0.000**	0.976	-0.267	0.596	**0.020**
Overjet	0.909	-0.003	0.354	0.963	0.893	-0.045	0.373	0.511	0.967	-0.025	0.217	0.528	0.917	0.068	0.317	0.252
Overbite	0.965	-0.049	0.240	0.269	0.932	-0.093	0.381	0.192	0.996	-0.012	0.078	0.404	0.967	0.056	0.278	0.282
Right Sag Rel	0.970	-0.122	0.435	0.135	0.850	0.163	0.962	0.360	0.948	-0.303	0.566	**0.007**	0.884	0.017	0.855	0.912
Left Sag Rel	0.975	-0.102	0.405	0.178	0.918	0.014	0.720	0.918	0.922	-0.105	0.701	0.419	0.962	-0.011	0.500	0.908

3Shape OA: 3shape models measured in Ortho Analyzer software; 3Shape DM: 3Shape models measured in Digimodel software. OrthoProof OA: OrthoProof models measured in Ortho Analyzer software; OrthoProof DM: OrthoProof models measured in Digimodel software.

DISCUSSION

Nowadays the orthodontist can use several types of plaster model and impression scanners with different technologies combined with several measuring software with inumerous possibilities.[27] As digital models can be used to replace the conventional plaster models, it is necessary to perform studies to evaluate if all methods of making digital models are reliable and if the software used for measurements on these digital models is interchangeable.

In this study a laser scanner and a CT scanner were used for making a digital model from a series of plaster models. It was found that the laser scanner method provides a model with a subjectively better texture and more details than the digital models made by the CT scanning method, but the accuracy of the measurements on both digital models was similar. Several earlier studies evaluated the accuracy of digital models made by laser scanning of the plaster model,[1,4-22] and of digital models made by CT scanners,[4,23,24] but only one study compared the differences in accuracy of measurements between these processing methods. In that study, it was concluded that the digital models by CT scanning were more accurate and reliable compared to the laser scanning method.[4]

The statistically significant differences in measurements between the plaster models and digital models found in this current study were slight. 3Shape models measured with Digimodel software presented more parameters with clinically significant differences, including the sum of 6 upper teeth. For the measurements on 3Shape models and OrthoProof models with Ortho Analyzer software only two differences in distances measured were clinically significant. For OrthoProof models measured with Digimodel software, only one measurement was clinically significant different. Dental diameters and crown heights were very reliable. The parameters with larger differences were the upper intercanine distance and the overbite. These differences can be caused by actual differences but also by the subjectivity of the measuring method. The intercanine distance measurement can be hampered by some attrition of the canine which can lead to misinterpretation in the correct marking of points. Regarding the overbite, the thickness of the tip of the calipers may have contributed to inaccuracies in this parameter on plaster casts,[22] while in digital models the possibility to magnify and to make a model cross-section combined with the small reference cursor for measurement, facilitates accuracy point identification compared to the measurement procedure on plaster models (Fig 2).

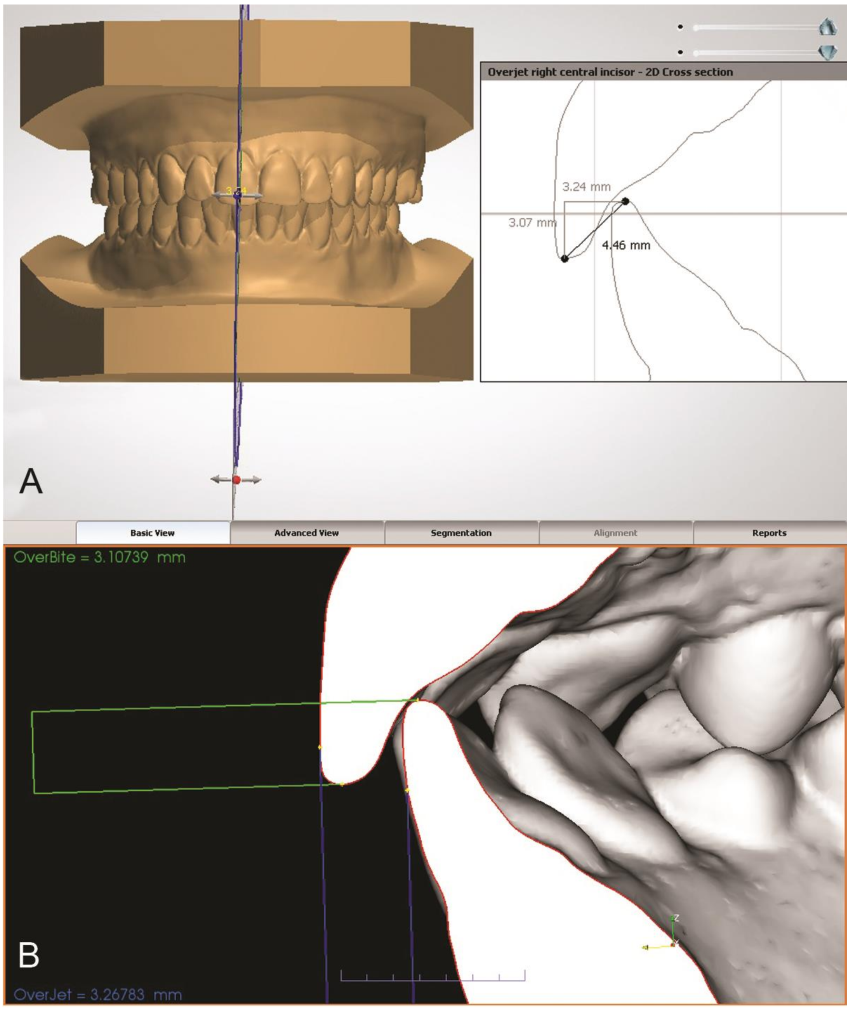

Fig 2. A, Measuring overbite in Ortho Analyzer software; **B**, measuring overjet and overbite in Digimodel software.

The transversal and sagittal parameters did not present any clinically significant difference in all digital models comparisons, which suggest that it is easier to mark the points on digital models than in plaster models. On digital models the user can click the marking point and change it if necessary, while on plaster models if the user hand is not stable, mistakes can happen during points marking. Furthermore, there is no physical barrier dictating placement of the measurement points in digital models.[6] Therefore, differences could also be caused by some errors of the measurement method. The results show that it is possible to use Ortho Analyzer or Digimodel software to measure a digital model made with two different methods with no significant changes in the measurements.

Regarding the measurement tools, the direct measure tool was used to make the measurements on digital models for almost all parameters, except for overjet and overbite. This tool is quite similar for both software. The Ortho Analyzer software provides an arrow when marking the point and a dashed line between the marked points which helps to evaluate their vertical and horizontal position (Fig 3A). Digimodel software only shows the marked points as a blue dot without a dashed line between them (Fig 3B). The overjet and overbite measurements were done by “clipping” the model, which enables a cross section view of the models and facilitates the measuring (Fig 2). The reference of the cross section for these measurements in this study was the center of upper right central incisor. This measurement method in both software is “user friendly” and the measurement can be made easily. The results of the measurements of the overjet and overbite showed no statistically significant differences for all the digital models comparisons. This indicates a difference in accuracy of the digital measuring method compared with the conventional measurement method with a caliper used for measuring plaster models.

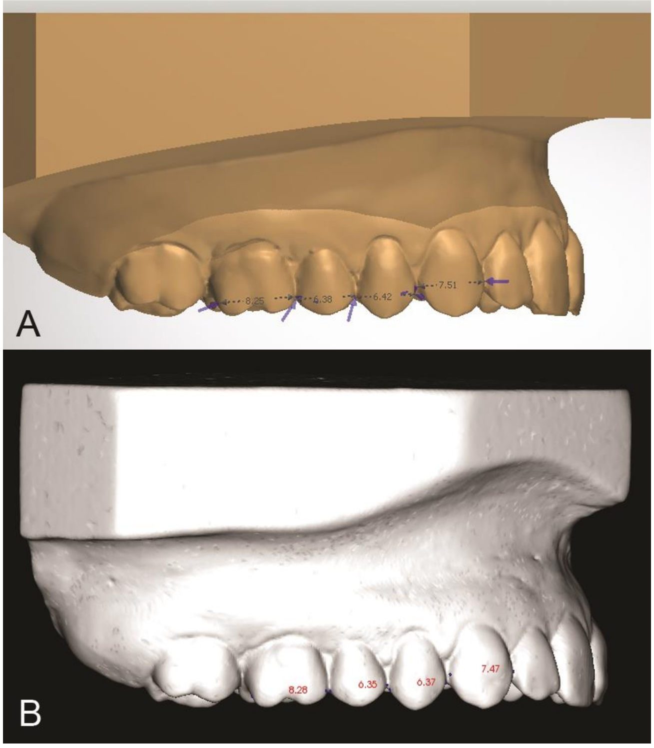

Fig 3. A, Measuring dental diameters in Ortho Analyzer software; **B**, measuring dental diameters in Digimodel software.

The occlusion of the digital models was determined in different ways. In the 3Shape models, it was acquired during the scanning process and could be adjusted in the software if needed, while the occlusion in Ortho Proof models was determined after the scanning process by dental technicians, who adjusted the relation of the upper and lower models with software, according the scanned bite registration. The method to obtain the inter arch relationship in the Orthoproof models may cause some errors due to the subjectivity of the operator,[26,30] but according to the results of this study, none of the interarch relationship parameters presented any clinically significant difference. So both methods of occlusion adjustment were considered to be accurate.

New technologies, such as the use of digital models, must be reproducible. Digital models will be used by different operators (orthodontists, maxillofacial surgeons, implantologists and lab technicians). In our study, interexaminer reliability was excellent in most cases and good for some others; this finding is in accordance with previous studies.[4,6,13] The largest difference in the measurement values was the measurement of the sagittal relationship parameter, for both the plaster and digital models (Table II).

Ideally, direct methods should be used for making digital models, because reduction of steps in dental model fabrication should lead to more accurate dental models. Furthermore, the process of making direct dental scanning, transportation by internet and storage of the digital models in the cloud is much easier and safer. Manufacturers should provide orthodontists with functional intraoral scanners, as well as an integrated software system that can be used for accurate, reliable and easy to use analysis of the dentition. The same software should be used to analyze files from different digital models. The orthodontist can choose to refer a patient to an orthodontic lab to fabricate the digital models or purchase a desktop scanner for plaster models and impressions, or an intraoral scanner to make the digital models in his/ her own dental office. That’s up to the decision of the practitioner. In this study we found that digital models made with a desktop laser scanner or a CT scanner, measured with Ortho Analyzer or Digimodel software presented similar results, so these methods are interchangeable and accurate.

CONCLUSION

Digital models made from a series of plaster models with the R700 laser scanner and the Flash CT scanner are accurate and reliable and can replace the conventional plaster models. Only a few clinical significant differences in measurements were found. Measurements on these digital models made with two different software are accurate so both fabrication methods and software are interchangeable.

Acknowledgments

We would like to thank the National Counsel of Technological and Scientific Development (CNPq) for the scholarship supporting the first author's PhD during the development of this study and Barra Laudo company, for enabling the scanning of the plaster models with 3Shape scanner used in this work

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4 – CONCLUSÕES

A partir das pesquisas realizadas, pode-se concluir que:

Modelos digitais por escaneamento de moldagens em silicone de adição apresentam acurácia e confiabilidade clinicamente aceitáveis, independentemente do tipo de base leve utilizada, mesmo em um período pós-moldagem de até 15 dias.

Modelos digitais por escaneamento intrabucal apresentam acurácia e reprodutibilidade clinicamente aceitáveis, podendo substituir os modelos de gesso convencionais.

Modelos digitais a partir do escaneamento de modelos de gesso por scanner a laser ou por tomografia computadorizada apresentam acurácia e confiabilidade clinicamente aceitáveis, independentemente do programa de medição utilizado, Ortho Analyzer (3Shape) ou Digimodel (OrthoProof).

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6 – ANEXOS

ANEXO A – Carta de aceite do artigo 1 no American Journal of Orthodontics and Dentofacial Orthopedics

Ms. Ref. No.: AJODO-D-14-00785R3

Title: Effect of PVS material and impression handling on the accuracy of digital models.

American Journal of Orthodontics & Dentofacial Orthopedics

Dear Mr. Camardella,

Thank you for revising and resubmitting your manuscript. I sent the recent revision back to the original referees, who are now satisfied that all necessary changes have been made and they recommend acceptance and publication of your research in the AJO-DO. Congratulations.

One of the reviewers suggested that figures 1, 3, 4 and 5 could be omitted. We will consider this when we prepare the article for publication.

I look forward to seeing the article in the AJO-DO. When we approach the publication date, I will send you more information about the proofing process and your publication date.

With kind regards,

Rolf Behrents

Editor-in-Chief

American Journal of Orthodontics and Dentofacial Orthopedics

Manuscript submission: www.ees.elsevier.com/ajodo

Journal website: www.ajodo.org

FACULDADE DE MEDICINA DA
UNIVERSIDADE FEDERAL
FLUMINENSE/ FM/ UFF/ HU

PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: Avaliação da precisão e confiabilidade de medidas de modelos digitais em ortodontia.

Pesquisador: OSWALDO DE VASCONCELLOS VILELLA
Área Temática:
Versão: 2
CAAE: 09651012.3.0000.5243
Instituição Proponente: Universidade Federal Fluminense
Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 221.664
Data da Relatoria: 01/02/2013

Apresentação do Projeto:

O modelo digital aplicado em ortodontia pode se tornar em breve uma realidade no consultório odontológico, pois apresenta diversas vantagens, como: diminuir custos com materiais de moldagem e modelagem; agilizar a confecção do modelo de estudo sem risco de fraturas; melhorar a comunicação entre colegas e com os laboratórios de prótese; facilitar e obter maior precisão na medição de valores em análises de modelo e na confecção de "setups"; e reduzir os espaços físicos necessários para o arquivamento desses modelos, permitindo ainda a duplicação digital em forma de "backups". Os modelos digitais apresentam precisão e confiabilidade aceitáveis para serem aplicados como método de diagnóstico e auxiliar o planejamento em ortodontia, no entanto, ainda não existem trabalhos que avaliassem a precisão e confiabilidade de modelos digitais disponibilizados por empresas brasileiras. Para isso serão selecionados 30 indivíduos e realizadas moldagem em alginato para confecção de modelo de estudo em gesso, moldagem em silicona de adição para envio para digitalização e escaneamento intrabucal da oclusão. Será avaliado se existem diferenças em relação à precisão das medidas entre os modelos de gesso e os modelos digitais. Os sujeitos da pesquisa deverão ter a presença de dentadura permanente com todos os dentes totalmente irrompidos (no mínimo de 1º molar a 1º molar permanente superior e inferior); ausência de anomalias de número, tamanho e forma; presença de dentes sem abrasões, atrições e erosões visíveis, e sem cáries ou restaurações que comprometam o diâmetro mesiodistal de suas coroas dentárias. Será realizado um exame clínico, fotografias intra e extrabucais,moldagem em alginato para confecção de modelo de estudo em gesso, moldagem em silicona de adição para envio para digitalização e escaneamento intrabucal da oclusão. Serão realizadas diversas medições nos modelos de estudos e nos modelos digitais adquiridos por duas empresas: Widia Labs e Compass. Dois examinadores devidamente calibrados para a medição dos modelos de gesso e digitais realizarão as medidas dos modelos adquiridos por todos os processos e repetirão após 15 dias, as medições de uma parte da amostra selecionada de forma aleatória para

realização do erro do método. O teste t pareado será utilizado para comparar a precisão das medidas entre os modelos de gesso e os modelos digitais fornecidos pela empresa Widia Labs por utilizar somente 1 (um) método de aquisição de modelo digital. A análise de variância será empregada para as medidas repetidas para a empresa Compass, que utiliza três métodos de aquisição de modelo digital, com o objetivo de verificar a presença de diferenças estatísticas entre elas. O software SPSS, versão 17, será utilizado para a obtenção dos resultados dos testes estatísticos, adotando-se o nível de significância de 5% de probabilidade (p0.05).

Objetivo da Pesquisa:

Identificar se existem diferenças em relação à precisão das medidas entre os modelos de gesso e os modelos digitais obtidos por três diferentes métodos: digitalização do modelo de gesso, digitalização da moldagem e digitalização por scanner intrabucal.

Avaliação dos Riscos e Benefícios:

Riscos:

Não há risco para os participantes da pesquisa.

Benefícios:

Caso seja demonstrado um grau aceitável de precisão e confiabilidade, a utilização dos modelos digitais de forma rotineira em ortodontia apresenta diversas vantagens, tais como: diminuir custos com materiais de moldagem e modelagem; evitar o desconforto da técnica de moldagem; agilizar a confecção do modelo de estudo sem risco de fraturas; melhorar a comunicação entre colegas e com os laboratórios de prótese; confeccionar diagramas individualizados; facilitar e obter maior precisão na medição em análises de modelo e na confecção de setups; e reduzir os espaços físicos necessários para o arquivamento desses modelos, permitindo ainda a duplicação digital em forma de backups.

Comentários e Considerações sobre a Pesquisa:

A pesquisa é pertinente, possuindo riscos mínimos e benefícios consideráveis para a população bem como para os profissionais da odontologia, pois permitirá a utilização com maior confiança de uma ferramenta que irá agilizar o procedimento bem como trazer resultados mais precisos para uma melhor avaliação na ortodontia. Os gastos da pesquisa serão custeados pelo próprio do pesquisador. Os dados serão coletados nas dependências do Departamento de Ortodontia da Universidade Federal Fluminense.

Considerações sobre os Termos de apresentação obrigatória:

Foram apresentados os todos os termos obrigatórios.

Recomendações:

Conclusões ou Pendências e Lista de Inadequações:

aprovado

Situação do Parecer:

Aprovado

Necessita Apreciação da CONEP:

Não

Considerações Finais a critério do CEP:

NITEROI, 18 de Março de 2013

Assinador por:
ROSANGELA ARRABAL THOMAZ
(Coordenador)

ANEXO C – Carta de comprovação de estudo no exterior pela Radboud University Medical Center, Nijmegen, Holanda

Radboudumc

Radboud University Medical Center
Department of Dentistry

Orthodontics and Craniofacial Biology

PO Box 9101, 6500 HB Nijmegen
Huispost 309
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T (024) 361 4005
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Head:
Dr. J.G.J.H. Schols
orthodontics@dent.umcn.nl
www.radboudumc.nl

To whom it may concern

Date	Our reference	Your reference
August 30, 2015	JS 14.067	

This is to certify that **Dr. Leonardo Camardella** has been working at the department of Orthodontics and Craniofacial Biology, Radboud University Medical Centre from March 2015 until present.

During this period he has held the following position:
Clinical research fellow and PhD candidate (March 2015 to September 2015)

During this period, his job duties and responsibilities comprised:

- Scientific research and activities:

Dr. Camardella has been working in collaboration with the 3D Facial Imaging Research Group Nijmegen. He has actively participated in ongoing research projects. He has also attended and participated in various departmental seminars, courses and scientific activities.

- Clinical duties:

none

- Teaching responsibilities:

none

Dr. Camardella is sincere, professional, hardworking and interacts very well with his colleagues.
During his employment, he proved to possess good communication skills and was able to apply his knowledge quite well in the various research activities.

Jan G.J.H. Schols, DDS PhD
Head of the Department of Orthodontics and Craniofacial Biology

Radboudumc
Radboud university medical center

ANEXO D - Artigo 1 – Comparação entre modelos de gesso e modelos digitais por escaneamento da moldagem em silicone de adição (examinador 1)

Parâmetro	Medida (mm)		Medida (mm)		Diferença média entre os métodos (mm)	Desvio padrão (mm)	Valor de *p*
	Modelos de gesso N = 30		Modelos digitais N = 30				
	Média	DP	**Média**	DP			
DMD 16	9,4123	0,57559	9,0587	0,48039	0,35367	0,31381	**0,000**
DMD 15	6,4350	0,49282	6,5900	0,46221	-0,15500	0,17950	**0,000**
DMD 14	6,8350	0,46752	6,9547	0,47759	-0,11967	0,13606	**0,000**
DMD 13	7,6133	0,48870	7,6803	0,52378	-0,06700	0,28522	0,208
DMD 12	6,4493	0,61246	6,5173	0,63650	-0,06800	0,19691	0,069
DMD 11	8,3870	0,49075	8,3157	0,51808	0,07133	0,19084	0,050
DMD 21	8,4267	0,47421	8,3683	0,52904	0,05833	0,26811	0,243
DMD 22	6,5090	0,58188	6,5167	0,54480	-0,00767	0,21455	0,846
DMD 23	7,6283	0,52188	7,5317	0,54519	0,09667	0,22480	**0,025**
DMD 24	6,8880	0,55039	7,0197	0,51266	-0,13167	0,16655	**0,000**
DMD 25	6,4427	0,50672	6,2800	0,43567	0,16267	0,20670	**0,000**
DMD 26	9,4480	0,55031	9,1477	0,48348	0,30033	0,32427	**0,000**
Soma 6 Sup	45,0137	2,53527	44,9300	2,66187	0,08367	0,81961	0,580
Soma 12 sup	90,4747	4,93441	89,9807	4,91074	0,49400	1,20884	**0,033**
DMD 36	10,6700	0,61149	10,8403	0,59327	-0,17033	0,25551	**0,001**
DMD 35	6,8383	0,43629	6,6920	0,44752	0,14633	0,24498	**0,003**
DMD 34	6,8627	0,43883	6,9570	0,44557	-0,09433	0,17926	**0,007**
DMD 33	6,4853	0,48568	6,6897	0,47843	-0,20433	0,21782	**0,000**
DMD 32	5,7670	0,39315	5,7670	0,45803	0,00000	0,22583	1,000
DMD 31	5,2903	0,31841	5,2390	0,45531	0,05133	0,32079	0,388
DMD 41	5,2910	0,35780	5,1813	0,36290	0,10967	0,22445	**0,012**
DMD 42	5,7163	0,42878	5,6470	0,42856	0,06933	0,23588	0,118
DMD 43	6,4277	0,43402	6,6130	0,50974	-0,18533	0,24933	**0,000**
DMD 44	6,8417	0,43519	6,8400	0,49043	0,00167	0,24465	0,970
DMD 45	6,8170	0,46581	6,7310	0,43304	0,08600	0,20544	**0,029**
DMD 46	10,5260	0,61460	10,7183	0,63329	-0,19233	0,22924	**0,000**
Soma 6 inf	34,9777	2,12390	35,1370	2,19172	-0,15933	0,76068	0,261
Soma 12 inf	83,5333	4,34535	83,9157	4,42245	-0,38233	1,21464	0,095
ALT 16	6,7207	0,86131	6,8507	0,74384	-0,13000	0,66632	0,294

ANEXO D - Artigo 1 – Comparação entre modelos de gesso e modelos digitais por escaneamento da moldagem em silicone de adição (examinador 1)

ALT 15	7,0013	0,84794	7,1563	0,91018	-0,15500	0,34250	**0,019**
ALT 14	8,0623	0,90080	8,0717	0,82017	-0,00933	0,49698	0,919
ALT 13	9,1987	0,78113	9,2223	0,78327	-0,02367	0,37870	0,735
ALT 12	8,2353	0,95811	8,2120	0,83914	0,02333	0,45373	0,780
ALT 11	9,5933	0,90696	9,7260	0,86920	-0,13267	0,42302	0,097
ALT 21	9,5627	0,92489	9,6860	0,84500	-0,12333	0,40575	0,107
ALT 22	8,2643	0,76876	8,3097	0,76362	-0,04533	0,43119	0,569
ALT 23	9,1373	0,86648	9,3087	0,78126	-0,17133	0,29263	**0,003**
ALT 24	8,1753	0,96916	8,1987	0,91929	-0,02333	0,24469	0,605
ALT 25	6,8527	0,80244	6,8930	0,89261	-0,04033	0,22844	0,342
ALT 26	6,6813	0,75113	6,8220	0,73015	-0,14067	0,39573	0,061
ALT 36	6,7553	0,58352	6,7597	0,60024	-0,00433	0,40676	0,954
ALT 35	7,4157	0,88395	7,2477	0,90736	0,16800	0,39311	**0,026**
ALT 34	8,2553	0,85492	7,9063	0,93572	0,34900	0,45912	**0,000**
ALT 33	9,2643	1,19636	8,9427	1,23045	0,32167	0,34209	**0,000**
ALT 32	8,2260	0,93009	8,1147	0,85199	0,11133	0,47433	0,209
ALT 31	8,0943	0,79970	8,0610	0,71849	0,03333	0,39825	0,650
ALT 41	8,2203	0,75397	8,0603	0,66606	0,16000	0,36113	**0,022**
ALT 42	8,2850	0,95172	8,0713	0,83463	0,21367	0,43608	**0,012**
ALT 43	9,1877	1,07220	8,9527	1,06335	0,23500	0,38350	**0,002**
ALT 44	8,2063	0,92852	8,0713	0,87348	0,13500	0,29061	**0,017**
ALT 45	7,4447	0,71974	7,3253	0,80983	0,11933	0,37044	0,088
ALT 46	7,0140	0,65637	6,9147	0,77581	0,09933	0,47623	0,263
DIC sup	33,7823	1,95206	33,4913	2,00142	0,29100	0,49786	**0,003**
DIC inf	25,0290	1,70777	25,3493	1,65649	-0,32033	0,41324	**0,000**
DIM sup	50,6340	3,10677	50,4157	3,07388	0,21833	0,36344	**0,003**
DIM inf	43,6330	2,57131	43,9223	2,57940	-0,28933	0,72336	**0,037**
Overjet	2,6930	0,82033	2,5883	0,93963	0,10467	0,41557	0,178
Overbite	2,7927	0,86768	2,1673	0,88382	0,62533	0,58319	**0,000**
Rel sag dir 1	21,3343	1,48122	21,1007	1,40704	0,23367	0,81930	0,129
Rel sag esq 1	21,0843	1,42227	21,0277	1,25139	0,05667	0,66726	0,645
Rel sag dir 2	22,1543	1,68923	22,2920	1,88175	-0,13767	1,02846	0,469
Rel sag esq 2	21,6920	1,80840	21,9563	1,69608	-0,26433	0,60153	**0,023**

ANEXO E - Artigo 1 – Comparação entre modelos de gesso e modelos digitais por escaneamento da moldagem em silicone de adição (examinador 2)

Parâmetro	Medida (mm)		Medida (mm)		Diferença média entre os métodos (mm)	Desvio padrão (mm)	Valor de *p*
	Modelos de gesso N = 30		Modelos digitais N = 30				
	Média	DP	**Média**	DP			
DMD 16	9,6170	0,58282	9,4207	0,60723	0,19633	0,47092	**0,030**
DMD 15	6,3773	0,46671	6,3187	0,54937	0,05867	0,36955	0,392
DMD 14	6,9843	0,53365	6,8627	0,50103	0,12167	0,30791	**0,039**
DMD 13	7,7610	0,51469	7,4803	0,67397	0,28067	0,44323	**0,002**
DMD 12	6,5963	0,63587	6,1347	0,68222	0,46167	0,32275	**0,000**
DMD 11	8,4570	0,53129	8,1130	0,59370	0,34400	0,40924	**0,000**
DMD 21	8,4670	0,50936	8,1653	0,49591	0,30167	0,30886	**0,000**
DMD 22	6,6177	0,58609	6,2067	0,62056	0,41100	0,29267	**0,000**
DMD 23	7,7777	0,54393	7,2593	0,42612	0,51833	0,32943	**0,000**
DMD 24	7,0400	0,56800	6,8373	0,48470	0,20267	0,33329	**0,002**
DMD 25	6,6327	0,60599	6,2620	0,54141	0,37067	0,47562	**0,000**
DMD 26	9,4593	0,52783	9,3400	0,56204	0,11933	0,40719	0,119
Soma 6 Sup	45,6767	2,59069	43,3593	2,50344	2,31733	1,00013	**0,000**
Soma 12 sup	91,7873	5,03158	88,4007	4,65782	3,38667	1,76215	**0,000**
DMD 36	10,7187	0,66903	10,6753	0,64265	0,04333	0,34236	0,494
DMD 35	6,8577	0,44725	6,7060	0,47217	0,15167	0,40246	**0,048**
DMD 34	7,0357	0,43092	6,8293	0,45695	0,20633	0,23751	**0,000**
DMD 33	6,5977	0,45148	6,6090	0,49725	-0,01133	0,30842	0,842
DMD 32	5,8673	0,42339	5,5233	0,52730	0,34400	0,40867	**0,000**
DMD 31	5,3960	0,28656	5,0400	0,36446	0,35600	0,31390	**0,000**
DMD 41	5,3730	0,36041	5,0337	0,43929	0,33933	0,30363	**0,000**
DMD 42	5,7887	0,38145	5,4713	0,48398	0,31733	0,51840	**0,002**
DMD 43	6,5767	0,51819	6,4740	0,55807	0,10267	0,43797	0,209
DMD 44	6,9643	0,50667	6,6277	0,47537	0,33667	0,35844	**0,000**
DMD 45	6,7720	0,42279	6,7340	0,48390	0,03800	0,39057	0,598
DMD 46	10,6627	0,64437	10,7350	0,64465	-0,07233	0,30728	0,207
Soma 6 inf	35,5993	2,03359	34,1513	2,08992	1,44800	1,12413	**0,000**
Soma 12 inf	84,6103	4,24636	82,4587	4,16007	2,15167	1,83321	**0,000**
ALT 16	6,8653	0,80576	6,9647	1,12632	-0,09933	0,47454	0,261

ANEXO E - Artigo 1 – Comparação entre modelos de gesso e modelos digitais por escaneamento da moldagem em silicone de adição (examinador 2)

ALT 15	6,9500	0,82100	7,1330	0,95704	-0,18300	0,41729	**0,023**
ALT 14	7,9753	0,90054	8,1623	0,88938	-0,18700	0,40896	**0,018**
ALT 13	9,1923	0,88057	9,3627	0,86199	-0,17033	0,39496	**0,025**
ALT 12	8,1080	0,89464	8,2657	0,86451	-0,15767	0,38115	**0,031**
ALT 11	9,5683	0,93195	9,7760	0,87077	-0,20767	0,36769	**0,004**
ALT 21	9,4833	0,94739	9,7517	0,92106	-0,26833	0,36566	**0,000**
ALT 22	8,1970	0,75048	8,3173	0,76902	-0,12033	0,42613	0,133
ALT 23	9,0960	0,84216	9,2700	0,84035	-0,17400	0,27372	**0,002**
ALT 24	7,9913	0,88760	8,1933	0,91709	-0,20200	0,26102	**0,000**
ALT 25	6,6230	0,77392	6,7977	0,83798	-0,17467	0,21665	**0,000**
ALT 26	6,4953	0,78380	6,4583	0,87226	0,03700	0,42487	0,637
ALT 36	6,8533	0,60479	6,8833	0,61030	-0,03000	0,28610	0,570
ALT 35	7,2520	0,80899	7,2163	0,98359	0,03567	0,62894	0,758
ALT 34	8,2153	0,98082	8,0317	1,05153	0,18367	0,44423	**0,031**
ALT 33	9,2007	1,17396	9,0490	1,24208	0,15167	0,50553	0,111
ALT 32	8,1577	0,94219	8,0340	0,93977	0,12367	0,58936	0,260
ALT 31	7,9603	0,80827	8,0993	0,82962	-0,13900	0,54617	0,174
ALT 41	8,1210	0,75623	8,1030	0,73350	0,01800	0,48473	0,840
ALT 42	8,2417	0,88062	8,0363	0,85616	0,20533	0,29358	**0,001**
ALT 43	9,1893	1,04045	8,9090	1,09382	0,28033	0,37660	**0,000**
ALT 44	8,0040	0,88284	8,0433	0,94472	-0,03933	0,32872	0,517
ALT 45	7,2563	0,79283	7,2633	0,86631	-0,00700	0,38547	0,921
ALT 46	6,8943	0,71503	6,9533	0,72400	-0,05900	0,42259	0,451
DIC sup	33,8517	2,03975	33,3517	1,90062	0,50000	0,59381	**0,000**
DIC inf	25,4893	1,90271	25,4223	1,62221	0,06700	0,80734	0,653
DIM sup	51,2107	3,24854	50,5017	3,10835	0,70900	0,49468	**0,000**
DIM inf	44,8103	2,69829	43,9787	2,52510	0,83167	0,69918	**0,000**
Overjet	2,9717	0,90057	2,4927	0,92453	0,47900	0,58106	**0,000**
Overbite	2,9940	0,85707	2,1420	0,90395	0,85200	0,50501	**0,000**
Rel sag dir 1	20,6420	1,52923	20,7933	1,59708	-0,15133	0,74642	0,276
Rel sag esq 1	20,7950	1,53353	20,8513	1,28447	-0,05633	0,94937	0,748
Rel sag dir 2	21,5423	1,65098	22,5163	1,94651	-0,97400	1,01983	**0,000**
Rel sag esq 2	21,5787	1,84321	21,6350	1,72339	-0,05633	0,98784	0,757

ANEXO F - Artigo 1 – Comparação entre modelos de gesso e modelos digitais por escaneamento da moldagem em silicone de adição (examinador 3)

Parâmetro	Medida (mm)		Medida (mm)		Diferença média entre os métodos (mm)	Desvio padrão (mm)	Valor de *p*
	Modelos de gesso N = 30		Modelos digitais N = 30				
	Média	DP	**Média**	DP			
DMD 16	9,3453	0,64992	9,2677	0,70317	0,07767	0,37108	0,261
DMD 15	6,3920	0,52147	6,3923	0,51896	-0,00033	0,24956	0,994
DMD 14	6,8440	0,51147	6,8477	0,48102	-0,00367	0,19370	0,918
DMD 13	7,6190	0,45258	7,4060	0,49593	0,21300	0,25289	**0,000**
DMD 12	6,4563	0,64867	6,3023	0,60408	0,15400	0,29754	**0,008**
DMD 11	8,3900	0,50494	8,1980	0,57220	0,19200	0,24742	**0,000**
DMD 21	8,4653	0,46908	8,2643	0,47657	0,20100	0,18138	**0,000**
DMD 22	6,5700	0,55544	6,3930	0,56917	0,17700	0,26269	**0,001**
DMD 23	7,6633	0,49525	7,4287	0,58741	0,23467	0,24601	**0,000**
DMD 24	6,8793	0,49713	6,8170	0,48753	0,06233	0,20080	0,100
DMD 25	6,4680	0,51682	6,3693	0,50658	0,09867	0,22082	**0,021**
DMD 26	9,3603	0,52341	9,3960	0,55277	-0,03567	0,36699	0,599
Soma 6 Sup	45,1640	2,44985	43,9923	2,50475	1,17167	0,68502	**0,000**
Soma 12 sup	90,4530	4,90599	89,0823	4,98873	1,37067	1,14105	**0,000**
DMD 36	10,6597	0,61451	10,6497	0,57894	0,01000	0,30472	0,859
DMD 35	6,7537	0,42085	6,8433	0,47036	-0,08967	0,23388	0,045
DMD 34	6,8353	0,43728	6,8217	0,45965	0,01367	0,21993	0,736
DMD 33	6,4360	0,43684	6,5310	0,50565	-0,09500	0,33155	0,127
DMD 32	5,7680	0,38349	5,7497	0,49588	0,01833	0,29821	0,739
DMD 31	5,3360	0,33347	5,1627	0,32398	0,17333	0,20220	**0,000**
DMD 41	5,3200	0,35837	5,1233	0,39112	0,19667	0,22886	**0,000**
DMD 42	5,7703	0,39983	5,6820	0,43375	0,08833	0,22749	**0,042**
DMD 43	6,4080	0,48142	6,4287	0,58771	-0,02067	0,28805	0,697
DMD 44	6,8587	0,43557	6,7697	0,41863	0,08900	0,15107	**0,003**
DMD 45	6,8050	0,43521	6,8870	0,46925	-0,08200	0,25295	0,086
DMD 46	10,5703	0,65990	10,6017	0,64072	-0,03133	0,25526	0,507
Soma 6 inf	35,0383	2,06274	34,6773	2,32060	0,36100	0,85854	**0,029**
Soma 12 inf	83,5210	4,19868	83,2503	4,55883	0,27067	0,96337	0,135
ALT 16	6,6080	0,87142	7,0777	0,93845	-0,46967	0,38463	**0,000**

ANEXO F - Artigo 1 – Comparação entre modelos de gesso e modelos digitais por escaneamento da moldagem em silicone de adição (examinador 3)

ALT 15	6,8463	0,84358	7,2927	0,89406	-0,44633	0,27249	**0,000**
ALT 14	7,9780	0,91366	8,2207	0,88956	-0,24267	0,44598	**0,006**
ALT 13	9,2323	0,85208	9,3697	0,78151	-0,13733	0,40733	0,075
ALT 12	8,1653	0,95239	8,3093	0,84265	-0,14400	0,37875	**0,046**
ALT 11	9,5557	0,92620	9,7107	0,86148	-0,15500	0,43961	0,063
ALT 21	9,5497	0,93524	9,6580	0,81071	-0,10833	0,35214	0,103
ALT 22	8,2063	0,79023	8,2560	0,76627	-0,04967	0,42063	0,523
ALT 23	9,1250	0,89761	9,3340	0,77640	-0,20900	0,31553	**0,001**
ALT 24	8,0457	0,99064	8,2400	0,89153	-0,19433	0,33963	**0,004**
ALT 25	6,7267	0,84523	6,9383	0,78563	-0,21167	0,28639	**0,000**
ALT 26	6,6023	0,81374	6,2863	0,95722	0,31600	0,59802	**0,007**
ALT 36	6,5573	0,63981	6,7067	0,73091	-0,14933	0,39065	0,045
ALT 35	7,2597	0,87509	7,1773	0,88692	0,08233	0,30113	0,145
ALT 34	8,0763	0,91564	7,9947	0,93273	0,08167	0,39023	0,261
ALT 33	9,1970	1,28632	9,0590	1,24252	0,13800	0,33646	**0,032**
ALT 32	8,1853	0,99747	8,1223	0,91128	0,06300	0,50067	0,496
ALT 31	8,0967	0,79143	8,0780	0,78438	0,01867	0,28889	0,726
ALT 41	8,1530	0,79116	8,1397	0,70791	0,01333	0,42416	0,864
ALT 42	8,2123	0,90058	8,0627	0,83225	0,14967	0,38662	**0,043**
ALT 43	9,1920	1,01265	8,9607	1,09458	0,23133	0,36922	**0,002**
ALT 44	8,0773	0,87333	8,1123	0,95910	-0,03500	0,31498	0,548
ALT 45	7,3330	0,83527	7,3810	0,85095	-0,04800	0,30772	0,400
ALT 46	6,8840	0,71270	7,0727	0,76716	-0,18867	0,37649	**0,010**
DIC sup	33,7017	1,96389	33,2543	1,96840	0,44733	0,48411	**0,000**
DIC inf	25,1773	1,75906	25,4500	1,78484	-0,27267	0,57205	**0,014**
DIM sup	50,6057	3,16697	50,5130	3,09641	0,09267	0,43617	0,254
DIM inf	44,5390	2,59935	44,2427	2,71653	0,29633	0,63378	**0,016**
Overjet	2,6303	0,92488	2,8787	0,92272	-0,24833	0,45543	**0,006**
Overbite	2,7287	0,85929	2,1927	0,91542	0,53600	0,54100	**0,000**
Rel sag dir 1	21,0317	1,43758	21,0353	1,53865	-0,00367	0,67347	0,976
Rel sag esq 1	21,1143	1,37988	20,6867	1,23478	0,42767	0,72132	**0,003**
Rel sag dir 2	21,8867	1,61741	22,3983	1,82750	-0,51167	0,98260	**0,008**
Rel sag esq 2	21,5377	1,77532	21,8087	1,64005	-0,27100	0,63721	**0,027**

ANEXO G - Artigo 2 – Comparação entre modelos de gesso e modelos digitais por escaneamento intrabucal - TRIOS Color (examinador 1)

Parâmetro	Medida (mm)		Medida (mm)		Diferença média entre os métodos (mm)	Desvio padrão (mm)	Valor de *p*
	Modelos de gesso N = 28		Modelos digitais N = 28				
	Média	DP	**Média**	DP			
DMD 16	9,3825	0,5808	9,2850	0,5012	0,0975	0,3336	0,1340
DMD 15	6,3850	0,4444	6,4543	0,4518	-0,0693	0,2619	0,1730
DMD 14	6,8246	0,4776	6,9329	0,4939	-0,1082	0,2275	**0,0180**
DMD 13	7,5507	0,4233	7,6025	0,3710	-0,0518	0,2150	0,2130
DMD 12	6,3736	0,5439	6,4268	0,5636	-0,0532	0,2386	0,2480
DMD 11	8,3336	0,4429	8,3304	0,4907	0,0032	0,1349	0,9010
DMD 21	8,3811	0,4503	8,3561	0,4630	0,0250	0,1420	0,3600
DMD 22	6,4579	0,5647	6,5550	0,4936	-0,0971	0,2193	**0,0270**
DMD 23	7,5607	0,4700	7,6932	0,5065	-0,1325	0,2395	**0,0070**
DMD 24	6,8400	0,5323	6,7757	0,4513	0,0643	0,1957	0,0940
DMD 25	6,3979	0,4658	6,4882	0,4808	-0,0904	0,2402	0,0570
DMD 26	9,4421	0,5627	9,3314	0,5021	0,1107	0,3603	0,1160
Soma 6 Sup	44,6575	2,2165	44,9639	2,2036	-0,3064	0,6177	**0,0140**
Soma 12 sup	89,9296	4,5769	90,2314	4,4464	-0,3018	1,1617	0,1810
DMD 36	10,6200	0,5990	10,8264	0,6049	-0,2064	0,2587	**0,0000**
DMD 35	6,7971	0,4120	6,7282	0,4218	0,0689	0,2841	0,2100
DMD 34	6,8504	0,4511	6,9411	0,5052	-0,0907	0,2013	**0,0240**
DMD 33	6,4307	0,4545	6,6089	0,5381	-0,1782	0,3877	**0,0220**
DMD 32	5,7211	0,3650	5,8064	0,4225	-0,0854	0,1751	**0,0160**
DMD 31	5,2514	0,2891	5,3343	0,2903	-0,0829	0,1232	**0,0010**
DMD 41	5,2479	0,3287	5,3039	0,3740	-0,0561	0,1878	0,1260
DMD 42	5,6754	0,4110	5,7671	0,4492	-0,0918	0,1230	**0,0010**
DMD 43	6,3775	0,4024	6,6264	0,5158	-0,2489	0,3128	**0,0000**
DMD 44	6,8250	0,4447	6,8289	0,4905	-0,0039	0,2310	0,9290
DMD 45	6,7507	0,4020	6,9843	0,4524	-0,2336	0,3228	**0,0010**
DMD 46	10,4696	0,5969	10,6818	0,6434	-0,2121	0,2729	**0,0000**
Soma 6 inf	34,7039	1,9173	35,4471	2,1307	-0,7432	0,6989	**0,0000**
Soma 12 inf	83,0168	4,0162	84,4379	4,3747	-1,4211	1,3974	**0,0000**
ALT 16	6,7300	0,8842	6,9261	0,8703	-0,1961	0,5411	0,0660

ANEXO G - Artigo 2 – Comparação entre modelos de gesso e modelos digitais por escaneamento intrabucal - TRIOS Color (examinador 1)

ALT 15	6,9639	0,8649	7,1950	0,9297	-0,2311	0,2939	**0,0000**
ALT 14	8,0939	0,9054	8,2164	0,9733	-0,1225	0,2464	**0,0140**
ALT 13	9,1864	0,8031	9,3293	0,8412	-0,1429	0,2751	**0,0110**
ALT 12	8,2525	0,9867	8,3789	0,9191	-0,1264	0,3221	**0,0470**
ALT 11	9,5964	0,9256	9,9407	0,9297	-0,3443	0,3268	**0,0000**
ALT 21	9,5404	0,9539	9,8711	0,9281	-0,3307	0,3140	**0,0000**
ALT 22	8,2586	0,7954	8,5707	0,7580	-0,3121	0,2884	**0,0000**
ALT 23	9,0964	0,8823	9,3439	0,8767	-0,2475	0,2767	**0,0000**
ALT 24	8,1932	0,9909	8,2904	1,0374	-0,0971	0,3491	0,1520
ALT 25	6,8161	0,8130	6,9675	0,8585	-0,1514	0,1583	**0,0000**
ALT 26	6,7014	0,7716	6,9657	0,9097	-0,2643	0,4267	**0,0030**
ALT 36	6,7443	0,6002	6,9257	0,7189	-0,1814	0,3799	**0,0180**
ALT 35	7,3900	0,8996	7,5682	0,8568	-0,1782	0,2580	**0,0010**
ALT 34	8,2314	0,8724	8,1718	0,9072	0,0596	0,4453	0,4850
ALT 33	9,1979	1,2100	9,1532	1,2086	0,0446	0,3452	0,5000
ALT 32	8,2725	0,9272	8,3004	0,9489	-0,0279	0,3179	0,6470
ALT 31	8,1207	0,8218	8,1621	0,7825	-0,0414	0,3166	0,4950
ALT 41	8,1886	0,7617	8,1679	0,7319	0,0207	0,2619	0,6790
ALT 42	8,2868	0,9175	8,2686	0,8153	0,0182	0,3886	0,8060
ALT 43	9,1164	1,0748	9,1118	1,0971	0,0046	0,3067	0,9370
ALT 44	8,2011	0,9524	8,2664	0,9397	-0,0654	0,2127	0,1160
ALT 45	7,4364	0,7364	7,5107	0,8095	-0,0743	0,3048	0,2080
ALT 46	7,0364	0,6638	7,1696	0,8661	-0,1332	0,4759	0,1500
DIC sup	33,5404	1,7750	33,1393	1,8221	0,4011	0,7423	**0,0080**
DIC inf	24,8568	1,6262	25,1632	1,6502	-0,3064	0,6918	**0,0270**
DIM sup	50,5336	3,1859	50,4954	3,2959	0,0382	0,3875	0,6060
DIM inf	43,4918	2,5675	43,9157	2,5813	-0,4239	0,6539	**0,0020**
Overjet	2,6657	0,7815	2,5579	0,9377	0,1079	0,3944	0,1590
Overbite	2,7421	0,8723	2,5604	0,9885	0,1818	0,5436	**0,0880**
Rel sag dir 1	21,2379	1,4581	21,1039	1,3503	0,1339	0,6044	0,2510
Rel sag esq 1	21,0029	1,3912	21,0496	1,1902	-0,0468	0,7144	0,7320
Rel sag dir 2	22,1196	1,7235	22,3625	1,7736	-0,2429	0,8521	0,1430
Rel sag esq 2	21,5768	1,7776	21,8689	1,6938	-0,2921	0,6197	**0,0190**

ANEXO H - Artigo 2 – Comparação entre modelos de gesso e modelos digitais por escaneamento intrabucal - TRIOS Color (examinador 2)

Parâmetro	Medida (mm)		Medida (mm)		Diferença média entre os métodos (mm)	Desvio padrão (mm)	Valor de *p*
	Modelos de gesso N = 28		Modelos digitais N = 28				
	Média	DP	**Média**	DP			
DMD 16	9,3179	0,6524	9,3489	0,5824	-0,0311	0,3634	0,6550
DMD 15	6,3461	0,4895	6,4175	0,4708	-0,0714	0,2093	0,0820
DMD 14	6,8257	0,5231	6,8611	0,4948	-0,0354	0,1934	0,3420
DMD 13	7,5571	0,3913	7,4718	0,4892	0,0854	0,3298	0,1820
DMD 12	6,3714	0,5749	6,2943	0,5610	0,0771	0,3014	0,1870
DMD 11	8,3375	0,4505	8,2261	0,4693	0,1114	0,1744	**0,0020**
DMD 21	8,4182	0,4443	8,2682	0,4402	0,1500	0,1579	**0,0000**
DMD 22	6,5250	0,5474	6,3682	0,5368	0,1568	0,2386	**0,0020**
DMD 23	7,6036	0,4544	7,4618	0,5227	0,1418	0,2423	**0,0050**
DMD 24	6,8479	0,4914	6,8611	0,4638	-0,0132	0,1843	0,7070
DMD 25	6,4296	0,4987	6,3732	0,4824	0,0564	0,1986	0,1440
DMD 26	9,3346	0,5309	9,3271	0,5554	0,0075	0,2912	0,8930
Soma 6 Sup	44,8129	2,1280	44,0904	2,2822	0,7225	0,7035	**0,0000**
Soma 12 sup	89,9146	4,5837	89,2793	4,6455	0,6354	0,9701	**0,0020**
DMD 36	10,6064	0,6012	10,6668	0,5823	-0,0604	0,2967	0,2910
DMD 35	6,7064	0,3915	6,7561	0,3805	-0,0496	0,2395	0,2820
DMD 34	6,8118	0,4435	6,8900	0,5395	-0,0782	0,2347	0,0890
DMD 33	6,4011	0,4297	6,5261	0,4581	-0,1250	0,1637	**0,0000**
DMD 32	5,7221	0,3524	5,7793	0,4365	-0,0571	0,2500	0,2370
DMD 31	5,2925	0,2996	5,3486	0,2912	-0,0561	0,1309	**0,0320**
DMD 41	5,2761	0,3283	5,2675	0,3317	0,0086	0,1585	0,7770
DMD 42	5,7361	0,3913	5,7407	0,4490	-0,0046	0,1759	0,8900
DMD 43	6,3593	0,4558	6,5718	0,5417	-0,2125	0,2342	**0,0000**
DMD 44	6,8396	0,4450	6,9518	0,4278	-0,1121	0,2058	**0,0080**
DMD 45	6,7607	0,4105	6,9336	0,4133	-0,1729	0,3220	**0,0080**
DMD 46	10,5236	0,6581	10,5743	0,6860	-0,0507	0,3292	0,4220
Soma 6 inf	34,7871	1,8901	35,2339	2,0148	-0,4468	0,5141	**0,0000**
Soma 12 inf	83,0357	3,8987	84,0064	4,1936	-0,9707	1,0010	**0,0000**
ALT 16	6,6350	0,8959	6,9461	1,0557	-0,3111	0,4358	**0,0010**

ANEXO H - Artigo 2 – Comparação entre modelos de gesso e modelos digitais por escaneamento intrabucal - TRIOS Color (examinador 2)

ALT 15	6,8079	0,8602	7,1336	0,9514	-0,3257	0,2948	**0,0000**
ALT 14	8,0089	0,9163	8,2586	0,9532	-0,2496	0,3241	**0,0000**
ALT 13	9,2279	0,8749	9,4232	0,8467	-0,1954	0,3087	**0,0020**
ALT 12	8,1618	0,9702	8,4832	0,8538	-0,3214	0,3335	**0,0000**
ALT 11	9,5600	0,9498	9,9686	0,9449	-0,4086	0,3659	**0,0000**
ALT 21	9,5414	0,9639	9,8671	0,9543	-0,3257	0,3884	**0,0000**
ALT 22	8,2096	0,8145	8,5418	0,7840	-0,3321	0,2427	**0,0000**
ALT 23	9,0882	0,9150	9,3404	0,8529	-0,2521	0,2725	**0,0000**
ALT 24	8,0518	1,0106	8,3264	1,0254	-0,2746	0,2885	**0,0000**
ALT 25	6,6871	0,8595	6,8668	0,8811	-0,1796	0,2064	**0,0000**
ALT 26	6,6193	0,8179	6,5146	1,0527	0,1046	0,4660	0,2450
ALT 36	6,5525	0,6628	6,7439	0,6879	-0,1914	0,3321	**0,0050**
ALT 35	7,2414	0,8977	7,3561	0,9278	-0,1146	0,3666	0,1100
ALT 34	8,0418	0,9267	8,1696	0,8911	-0,1279	0,3639	0,0740
ALT 33	9,1379	1,3106	9,2250	1,2437	-0,0871	0,2964	0,1310
ALT 32	8,2425	0,9940	8,2639	0,9989	-0,0214	0,2903	0,6990
ALT 31	8,1318	0,8078	8,1939	0,8061	-0,0621	0,3042	0,2890
ALT 41	8,1261	0,7948	8,2225	0,7129	-0,0964	0,2779	0,0770
ALT 42	8,2189	0,8740	8,2304	0,8352	-0,0114	0,2848	0,8330
ALT 43	9,1293	1,0199	9,1568	1,0597	-0,0275	0,3565	0,6860
ALT 44	8,0843	0,8927	8,1939	0,9833	-0,1096	0,2920	0,0570
ALT 45	7,3189	0,8544	7,5132	0,8290	-0,1943	0,3376	**0,0050**
ALT 46	6,8914	0,7354	7,1500	0,7573	-0,2586	0,4499	**0,0050**
DIC sup	33,4775	1,8284	33,2164	1,8362	0,2611	0,7222	0,0660
DIC inf	24,9779	1,6442	25,0629	1,7654	-0,0850	0,5883	0,4510
DIM sup	50,5164	3,2584	50,5029	3,2065	0,0136	0,4308	0,8690
DIM inf	44,4214	2,6240	44,3861	2,7330	0,0354	0,5652	0,7430
Overjet	2,8221	0,8942	2,8300	0,8886	-0,0079	0,2424	0,8650
Overbite	2,6661	0,8450	2,5386	0,9844	0,1275	0,5156	0,2020
Rel sag dir 1	20,9511	1,4197	21,0268	1,4269	-0,0757	0,6556	0,5460
Rel sag esq 1	21,0236	1,3404	21,0432	1,3762	-0,0196	0,7414	0,8900
Rel sag dir 2	21,7993	1,6277	22,4289	1,7203	-0,6296	0,8872	**0,0010**
Rel sag esq 2	21,4300	1,7489	22,0629	1,8502	-0,6329	0,6053	**0,0000**

ANEXO I - Artigo 3 – Comparação entre modelos de gesso e modelos digitais por escaneamento do modelo de gesso (3Shape) medido no programa DigiModel (examinador 1)

Parâmetro	Medida (mm)		Medida (mm)		Diferença média entre os métodos (mm)	Desvio padrão (mm)	Valor de *p*
	Modelos de gesso N = 30		Modelos digitais N = 30				
	Média	DP	**Média**	DP			
DMD 16	9,5980	0,5712	9,6943	0,5873	-0,0963	0,2753	0,0650
DMD 15	6,4497	0,5584	6,5333	0,5172	-0,0837	0,1853	**0,0190**
DMD 14	6,8813	0,4950	6,8960	0,4903	-0,0147	0,1413	0,5740
DMD 13	7,6967	0,4667	7,5523	0,4785	0,1443	0,1616	**0,0000**
DMD 12	6,5080	0,6380	6,2147	0,5932	0,2933	0,2136	**0,0000**
DMD 11	8,3957	0,5102	8,1477	0,5472	0,2480	0,1662	**0,0000**
DMD 21	8,4653	0,4691	8,3197	0,5399	0,1457	0,1692	**0,0000**
DMD 22	6,5637	0,5619	6,3820	0,5782	0,1817	0,1718	**0,0000**
DMD 23	7,6633	0,4953	7,5460	0,5360	0,1173	0,1326	**0,0000**
DMD 24	6,9047	0,4941	6,8887	0,4950	0,0160	0,1331	0,5150
DMD 25	6,4817	0,5017	6,5297	0,5095	-0,0480	0,1302	0,0530
DMD 26	9,4393	0,5292	9,5737	0,5190	-0,1343	0,1937	**0,0010**
Soma 6 Sup	45,2927	2,5215	44,1623	2,5590	1,1303	0,3942	**0,0000**
Soma 12 sup	91,0473	4,9500	90,2780	4,9789	0,7693	0,6634	**0,0000**
DMD 36	10,7610	0,6199	10,6980	0,6082	0,0630	0,2360	0,1550
DMD 35	6,9173	0,4330	6,9683	0,4617	-0,0510	0,2403	0,2550
DMD 34	6,9003	0,4634	6,8753	0,4614	0,0250	0,1806	0,4540
DMD 33	6,4910	0,4350	6,5317	0,4887	-0,0407	0,2124	0,3030
DMD 32	5,7883	0,3883	5,6543	0,4044	0,1340	0,1531	**0,0000**
DMD 31	5,3560	0,3374	5,1837	0,3250	0,1723	0,1333	**0,0000**
DMD 41	5,3150	0,3530	5,1880	0,3572	0,1270	0,1357	**0,0000**
DMD 42	5,7703	0,3998	5,6170	0,4146	0,1533	0,1551	**0,0000**
DMD 43	6,4640	0,4577	6,4517	0,4821	0,0123	0,1705	0,6950
DMD 44	6,8830	0,4212	6,7980	0,4256	0,0850	0,1713	**0,0110**
DMD 45	6,8253	0,3955	6,9210	0,4867	-0,0957	0,2408	**0,0380**
DMD 46	10,6067	0,6427	10,6020	0,6417	0,0047	0,2027	0,9000
Soma 6 inf	35,1847	2,0479	34,6263	2,1702	0,5583	0,4876	**0,0000**
Soma 12 inf	84,0783	4,1977	83,4890	4,4369	0,5893	0,9932	**0,0030**
ALT 16	6,5377	0,8429	6,8053	0,9199	-0,2677	0,2668	**0,0000**

ANEXO I - Artigo 3 – Comparação entre modelos de gesso e modelos digitais por escaneamento do modelo de gesso (3Shape) medido no programa DigiModel (examinador 1)

ALT 14	7,9777	0,9145	8,2037	0,9678	-0,2260	0,2879	**0,0000**
ALT 13	9,2243	0,8435	9,3340	0,8506	-0,1097	0,2015	**0,0060**
ALT 11	9,5473	0,9294	9,7177	0,8253	-0,1703	0,2083	**0,0000**
ALT 21	9,5777	0,9603	9,6753	0,9255	-0,0977	0,2129	**0,0180**
ALT 23	9,1163	0,9032	9,1867	0,8436	-0,0703	0,2052	0,0710
ALT 24	8,1347	1,0162	8,2320	0,9444	-0,0973	0,2522	**0,0430**
ALT 26	6,7683	0,8839	6,6827	0,7933	0,0857	0,3545	0,1960
ALT 36	6,6913	0,6856	7,0940	0,5782	-0,4027	0,2621	**0,0000**
ALT 34	8,0793	0,9094	8,3270	0,8593	-0,2477	0,3467	**0,0010**
ALT 33	9,2057	1,2345	9,4130	1,1701	-0,2073	0,2290	**0,0000**
ALT 31	8,0923	0,8306	8,2250	0,7975	-0,1327	0,2293	**0,0040**
ALT 41	8,1687	0,7719	8,2533	0,7190	-0,0847	0,2422	0,0650
ALT 43	9,1523	1,0662	9,2953	1,0126	-0,1430	0,2778	**0,0090**
ALT 44	8,1100	0,8998	8,1700	0,9423	-0,0600	0,2255	0,1560
ALT 46	6,9300	0,7618	7,1867	0,7564	-0,2567	0,2121	**0,0000**
DIC sup	33,7130	1,9978	33,2757	1,9511	0,4373	0,4097	**0,0000**
DIC inf	25,1880	1,7181	25,1637	1,7742	0,0243	0,4455	0,7670
DIM sup	50,6410	3,1673	50,6867	3,1849	-0,0457	0,5385	0,6460
DIM inf	44,0207	2,5260	43,9860	2,6677	0,0347	0,5080	0,7110
Overjet	2,9880	0,9331	2,9037	0,8156	0,0843	0,3311	0,1740
Overbite	2,7557	0,8563	2,4530	0,9089	0,3027	0,3207	**0,0000**
Rel sag dir 2	22,2500	1,6563	22,6733	1,6679	-0,4233	0,7233	**0,0030**
Rel sag esq 2	21,6667	1,7117	21,9053	1,6886	-0,2387	0,4152	**0,0040**

ANEXO J - Artigo 3 – Comparação entre modelos de gesso e modelos digitais por escaneamento do modelo de gesso (3Shape) medido no programa Ortho Analyzer (examinador 1)

Parâmetro	Medida (mm)		Medida (mm)		Diferença média entre os métodos (mm)	Desvio padrão (mm)	Valor de *p*
	Modelos de gesso N = 30		Modelos digitais N = 30				
	Média	DP	**Média**	DP			
DMD 16	9,5980	0,5712	9,6030	0,5369	-0,0050	0,1997	0,8920
DMD 15	6,4497	0,5584	6,4853	0,5592	-0,0357	0,2418	0,4260
DMD 14	6,8813	0,4950	6,9303	0,4970	-0,0490	0,1856	0,1590
DMD 13	7,6967	0,4667	7,6817	0,4906	0,0150	0,2323	0,7260
DMD 12	6,5080	0,6380	6,4513	0,6628	0,0567	0,1983	0,1280
DMD 11	8,3957	0,5102	8,3550	0,6054	0,0407	0,1952	0,2630
DMD 21	8,4653	0,4691	8,4373	0,5269	0,0280	0,1730	0,3830
DMD 22	6,5637	0,5619	6,4533	0,6239	0,1103	0,2296	**0,0130**
DMD 23	7,6633	0,4953	7,6350	0,5210	0,0283	0,1712	0,3720
DMD 24	6,9047	0,4941	7,0033	0,5144	-0,0987	0,1568	**0,0020**
DMD 25	6,4817	0,5017	6,5493	0,4854	-0,0677	0,1276	**0,0070**
DMD 26	9,4393	0,5292	9,6133	0,5335	-0,1740	0,2092	**0,0000**
Soma 6 Sup	45,2927	2,5215	45,0137	2,7354	0,2790	0,6433	**0,0240**
Soma 12 sup	91,0473	4,9500	91,1983	5,0794	-0,1510	0,9470	0,3900
DMD 36	10,7610	0,6199	10,7190	0,6255	0,0420	0,2213	0,3070
DMD 35	6,9173	0,4330	6,9210	0,4899	-0,0037	0,2978	0,9470
DMD 34	6,9003	0,4634	6,9490	0,4512	-0,0487	0,2144	0,2240
DMD 33	6,4910	0,4350	6,6477	0,5497	-0,1567	0,2863	**0,0060**
DMD 32	5,7883	0,3883	5,8293	0,4594	-0,0410	0,2502	0,3770
DMD 31	5,3560	0,3374	5,2793	0,3277	0,0767	0,1327	**0,0040**
DMD 41	5,3150	0,3530	5,3067	0,3876	0,0083	0,2029	0,8240
DMD 42	5,7703	0,3998	5,6927	0,4667	0,0777	0,1519	**0,0090**
DMD 43	6,4640	0,4577	6,5143	0,5003	-0,0503	0,2297	0,2400
DMD 44	6,8830	0,4212	6,8743	0,4522	0,0087	0,1861	0,8000
DMD 45	6,8253	0,3955	6,9470	0,4833	-0,1217	0,2689	**0,0190**
DMD 46	10,6067	0,6427	10,6217	0,6336	-0,0150	0,1561	0,6030
Soma 6 inf	35,1847	2,0479	35,2700	2,3511	-0,0853	0,6988	0,5090
Soma 12 inf	84,0783	4,1977	84,3020	4,6002	-0,2237	1,3012	0,3540
ALT 16	6,5377	0,8429	6,8963	0,9178	-0,3587	0,3303	**0,0000**

ANEXO J - Artigo 3 – Comparação entre modelos de gesso e modelos digitais por escaneamento do modelo de gesso (3Shape) medido no programa Ortho Analyzer (examinador 1)

ALT 14	7,9777	0,9145	8,1147	0,9652	-0,1370	0,2923	**0,0160**
ALT 13	9,2243	0,8435	9,3177	0,8769	-0,0933	0,2565	0,0560
ALT 11	9,5473	0,9294	9,6897	0,8815	-0,1423	0,2023	**0,0010**
ALT 21	9,5777	0,9603	9,6227	0,9568	-0,0450	0,2330	0,2990
ALT 23	9,1163	0,9032	9,1857	0,8968	-0,0693	0,2114	0,0830
ALT 24	8,1347	1,0162	8,2533	1,0442	-0,1187	0,2359	**0,0100**
ALT 26	6,7683	0,8839	6,5570	1,0119	0,2113	0,2881	**0,0000**
ALT 36	6,6913	0,6856	6,7887	0,6509	-0,0973	0,2673	0,0560
ALT 34	8,0793	0,9094	7,9923	1,0545	0,0870	0,5014	0,3500
ALT 33	9,2057	1,2345	9,1600	1,2670	0,0457	0,2123	0,2480
ALT 31	8,0923	0,8306	8,0627	0,8406	0,0297	0,2196	0,4650
ALT 41	8,1687	0,7719	8,1863	0,7808	-0,0177	0,1920	0,6180
ALT 43	9,1523	1,0662	9,2210	1,0611	-0,0687	0,2146	0,0900
ALT 44	8,1100	0,8998	8,0320	0,9512	0,0780	0,1988	**0,0400**
ALT 46	6,9300	0,7618	6,9470	0,7738	-0,0170	0,3310	0,7800
DIC sup	33,7130	1,9978	33,3860	1,9596	0,3270	0,4482	**0,0000**
DIC inf	25,1880	1,7181	25,3320	1,9187	-0,1440	0,4938	0,1210
DIM sup	50,6410	3,1673	50,6593	3,1656	-0,0183	0,4309	0,8170
DIM inf	44,0207	2,5260	44,3013	2,5843	-0,2807	0,4822	**0,0030**
Overjet	2,9880	0,9331	2,8783	0,8472	0,1097	0,2829	**0,0420**
Overbite	2,7557	0,8563	2,4410	0,8914	0,3147	0,2830	**0,0000**
Rel sag dir 2	22,2500	1,6563	22,3707	1,7785	-0,1207	0,6545	0,3210
Rel sag esq 2	21,6667	1,7117	21,8003	1,8144	-0,1337	0,6835	0,2930

ANEXO K - Artigo 3 – Comparação entre modelos de gesso e modelos digitais por escaneamento do modelo de gesso (OrthoProof) medido no programa DigiModel (examinador 1)

Parâmetro	Medida (mm)		Medida (mm)		Diferença média entre os métodos (mm)	Desvio padrão (mm)	Valor de *p*
	Modelos de gesso N = 30		Modelos digitais N = 30				
	Média	DP	**Média**	DP			
DMD 16	9,5980	0,5712	9,6943	0,5171	-0,0963	0,2282	**0,0280**
DMD 15	6,4497	0,5584	6,5797	0,5370	-0,1300	0,1726	**0,0000**
DMD 14	6,8813	0,4950	6,9747	0,4920	-0,0933	0,1671	**0,0050**
DMD 13	7,6967	0,4667	7,6893	0,5123	0,0073	0,2376	0,8670
DMD 12	6,5080	0,6380	6,3687	0,6157	0,1393	0,2201	**0,0020**
DMD 11	8,3957	0,5102	8,2917	0,5626	0,1040	0,1629	**0,0020**
DMD 21	8,4653	0,4691	8,3763	0,5489	0,0890	0,2070	**0,0260**
DMD 22	6,5637	0,5619	6,5210	0,5826	0,0427	0,2757	0,4040
DMD 23	7,6633	0,4953	7,7160	0,5206	-0,0527	0,2072	0,1740
DMD 24	6,9047	0,4941	6,9650	0,5716	-0,0603	0,1906	0,0940
DMD 25	6,4817	0,5017	6,5313	0,5162	-0,0497	0,1833	0,1490
DMD 26	9,4393	0,5292	9,6510	0,5144	-0,2117	0,1969	**0,0000**
Soma 6 Sup	45,2927	2,5215	44,9630	2,6434	0,3297	0,4488	**0,0000**
Soma 12 sup	91,0473	4,9500	91,3590	5,0704	-0,3117	0,6953	**0,0200**
DMD 36	10,7610	0,6199	10,4807	0,5569	0,2803	0,3602	**0,0000**
DMD 35	6,9173	0,4330	6,9497	0,5114	-0,0323	0,2730	0,5220
DMD 34	6,9003	0,4634	6,8980	0,4842	0,0023	0,2525	0,9600
DMD 33	6,4910	0,4350	6,5327	0,5107	-0,0417	0,2645	0,3950
DMD 32	5,7883	0,3883	5,6977	0,3869	0,0907	0,2560	0,0620
DMD 31	5,3560	0,3374	5,2650	0,4064	0,0910	0,3201	0,1300
DMD 41	5,3150	0,3530	5,2260	0,3277	0,0890	0,2231	**0,0370**
DMD 42	5,7703	0,3998	5,6680	0,4652	0,1023	0,1888	**0,0060**
DMD 43	6,4640	0,4577	6,5437	0,5988	-0,0797	0,2779	0,1270
DMD 44	6,8830	0,4212	6,8750	0,4696	0,0080	0,2527	0,8640
DMD 45	6,8253	0,3955	6,9233	0,4995	-0,0980	0,2751	0,0610
DMD 46	10,6067	0,6427	10,5093	0,6033	0,0973	0,2085	**0,0160**
Soma 6 inf	35,1847	2,0479	34,9330	2,2020	0,2517	0,7221	0,0660
Soma 12 inf	84,0783	4,1977	83,5690	4,3380	0,5093	1,0679	**0,0140**
ALT 16	6,5377	0,8429	6,6933	0,9352	-0,1557	0,4805	0,0860

ANEXO K - Artigo 3 – Comparação entre modelos de gesso e modelos digitais por escaneamento do modelo de gesso (OrthoProof) medido no programa DigiModel (examinador 1)

ALT 14	7,9777	0,9145	8,1413	0,9281	-0,1637	0,3035	**0,0060**
ALT 13	9,2243	0,8435	9,3887	0,8401	-0,1643	0,3462	**0,0150**
ALT 11	9,5473	0,9294	9,6047	0,9508	-0,0573	0,1792	0,0900
ALT 21	9,5777	0,9603	9,5503	0,9263	0,0273	0,2470	0,5490
ALT 23	9,1163	0,9032	9,1470	0,8391	-0,0307	0,3271	0,6120
ALT 24	8,1347	1,0162	8,0377	0,8886	0,0970	0,3623	0,1530
ALT 26	6,7683	0,8839	6,5087	0,7601	0,2597	0,3699	**0,0010**
ALT 36	6,6913	0,6856	6,9510	0,5852	-0,2597	0,4220	**0,0020**
ALT 34	8,0793	0,9094	8,2730	0,8419	-0,1937	0,4165	**0,0160**
ALT 33	9,2057	1,2345	9,4060	1,1087	-0,2003	0,4756	**0,0280**
ALT 31	8,0923	0,8306	8,2113	0,7039	-0,1190	0,3296	0,0580
ALT 41	8,1687	0,7719	8,2620	0,7053	-0,0933	0,2467	**0,0470**
ALT 43	9,1523	1,0662	9,4067	0,9938	-0,2543	0,5276	**0,0130**
ALT 44	8,1100	0,8998	8,1873	0,8759	-0,0773	0,2902	0,1550
ALT 46	6,9300	0,7618	6,9910	0,6806	-0,0610	0,2777	0,2390
DIC sup	33,7130	1,9978	33,3107	1,9599	0,4023	0,4421	**0,0000**
DIC inf	25,1880	1,7181	25,2080	1,8701	-0,0200	0,4760	0,8200
DIM sup	50,6410	3,1673	50,5230	3,1708	0,1180	0,7400	0,3900
DIM inf	44,0207	2,5260	44,0367	2,7124	-0,0160	0,6673	0,8960
Overjet	2,9880	0,9331	2,9490	0,7932	0,0390	0,4804	0,6600
Overbite	2,7557	0,8563	2,5460	1,0401	0,2097	0,5393	**0,0420**
Rel sag dir 2	22,2500	1,6563	22,5100	1,8082	-0,2600	1,0839	0,1990
Rel sag esq 2	21,6667	1,7117	21,8917	1,8196	-0,2250	0,6468	0,0670

ANEXO L - Artigo 3 – Comparação entre modelos de gesso e modelos digitais por escaneamento do modelo de gesso (OrthoProof) medido no programa Ortho Analyzer (examinador 1)

Parâmetro	Medida (mm)		Medida (mm)		Diferença média entre os métodos (mm)	Desvio padrão (mm)	Valor de *p*
	Modelos de gesso N = 30		Modelos digitais N = 30				
	Média	DP	**Média**	DP			
DMD 16	9,5980	0,5712	9,6787	0,5220	-0,0807	0,2253	0,0600
DMD 15	6,4497	0,5584	6,6210	0,5432	-0,1713	0,1539	**0,0000**
DMD 14	6,8813	0,4950	7,0270	0,5040	-0,1457	0,1574	**0,0000**
DMD 13	7,6967	0,4667	7,8370	0,4937	-0,1403	0,1853	**0,0000**
DMD 12	6,5080	0,6380	6,3737	0,5821	0,1343	0,2452	**0,0050**
DMD 11	8,3957	0,5102	8,4020	0,5341	-0,0063	0,1930	0,8590
DMD 21	8,4653	0,4691	8,4803	0,5150	-0,0150	0,2153	0,7060
DMD 22	6,5637	0,5619	6,5160	0,6092	0,0477	0,2830	0,3640
DMD 23	7,6633	0,4953	7,6863	0,5110	-0,0230	0,1717	0,4690
DMD 24	6,9047	0,4941	7,0850	0,5147	-0,1803	0,1340	**0,0000**
DMD 25	6,4817	0,5017	6,6060	0,5612	-0,1243	0,1771	**0,0010**
DMD 26	9,4393	0,5292	9,5937	0,5091	-0,1543	0,2209	**0,0010**
Soma 6 Sup	45,2927	2,5215	45,2953	2,5094	-0,0027	0,5556	0,9790
Soma 12 sup	91,0473	4,9500	91,9067	4,8726	-0,8593	0,7600	**0,0000**
DMD 36	10,7610	0,6199	10,7593	0,5430	0,0017	0,2302	0,9690
DMD 35	6,9173	0,4330	7,0403	0,4347	-0,1230	0,1772	**0,0010**
DMD 34	6,9003	0,4634	6,9847	0,4985	-0,0843	0,2086	**0,0350**
DMD 33	6,4910	0,4350	6,7497	0,5248	-0,2587	0,2228	**0,0000**
DMD 32	5,7883	0,3883	5,8660	0,4355	-0,0777	0,2136	0,0560
DMD 31	5,3560	0,3374	5,3557	0,3648	0,0003	0,1798	0,9920
DMD 41	5,3150	0,3530	5,3213	0,3953	-0,0063	0,1602	0,8300
DMD 42	5,7703	0,3998	5,7980	0,4693	-0,0277	0,1877	0,4260
DMD 43	6,4640	0,4577	6,6557	0,5259	-0,1917	0,2445	**0,0000**
DMD 44	6,8830	0,4212	6,9453	0,4585	-0,0623	0,1946	0,0900
DMD 45	6,8253	0,3955	7,0163	0,5158	-0,1910	0,2616	**0,0000**
DMD 46	10,6067	0,6427	10,6337	0,6121	-0,0270	0,2466	0,5530
Soma 6 inf	35,1847	2,0479	35,7463	2,2396	-0,5617	0,5975	**0,0000**
Soma 12 inf	84,0783	4,1977	85,1260	4,4486	-1,0477	0,8151	**0,0000**
ALT 16	6,5377	0,8429	6,8457	0,9025	-0,3080	0,3499	**0,0000**

ANEXO L - Artigo 3 – Comparação entre modelos de gesso e modelos digitais por escaneamento do modelo de gesso (OrthoProof) medido no programa Ortho Analyzer (examinador 1)

ALT 14	7,9777	0,9145	8,1997	0,9496	-0,2220	0,3108	**0,0010**
ALT 13	9,2243	0,8435	9,4217	0,8557	-0,1973	0,1767	**0,0000**
ALT 11	9,5473	0,9294	9,8217	0,9362	-0,2743	0,1824	**0,0000**
ALT 21	9,5777	0,9603	9,7833	0,9457	-0,2057	0,1922	**0,0000**
ALT 23	9,1163	0,9032	9,4207	0,8938	-0,3043	0,2076	**0,0000**
ALT 24	8,1347	1,0162	8,3937	0,9875	-0,2590	0,2102	**0,0000**
ALT 26	6,7683	0,8839	6,6583	0,8873	0,1100	0,3664	0,1110
ALT 36	6,6913	0,6856	6,9497	0,6305	-0,2583	0,2933	**0,0000**
ALT 34	8,0793	0,9094	8,2500	0,8681	-0,1707	0,3189	**0,0070**
ALT 33	9,2057	1,2345	9,3550	1,2243	-0,1493	0,2447	**0,0020**
ALT 31	8,0923	0,8306	8,1490	0,8175	-0,0567	0,2072	0,1450
ALT 41	8,1687	0,7719	8,1280	0,7442	0,0407	0,2835	0,4380
ALT 43	9,1523	1,0662	9,2907	1,0622	-0,1383	0,2793	**0,0110**
ALT 44	8,1100	0,8998	8,2463	0,9085	-0,1363	0,2229	**0,0020**
ALT 46	6,9300	0,7618	6,9920	0,7516	-0,0620	0,2831	0,2400
DIC sup	33,7130	1,9978	33,4280	2,0162	0,2850	0,4754	**0,0030**
DIC inf	25,1880	1,7181	25,3400	1,6923	-0,1520	0,5252	0,1240
DIM sup	50,6410	3,1673	50,5277	3,0915	0,1133	0,5143	0,2370
DIM inf	44,0207	2,5260	44,3033	2,6227	-0,2827	0,4835	**0,0030**
Overjet	2,9880	0,9331	2,8813	0,7534	0,1067	0,4128	0,1680
Overbite	2,7557	0,8563	2,4903	0,9166	0,2653	0,3789	**0,0010**
Rel sag dir 2	22,2500	1,6563	22,4927	1,7217	-0,2427	0,5960	**0,0340**
Rel sag esq 2	21,6667	1,7117	21,9023	1,7201	-0,2357	0,4845	**0,0120**

ANEXO M - Artigo 3 – Comparação entre modelos de gesso e modelos digitais por escaneamento do modelo de gesso (3Shape) medido no programa DigiModel (examinador 2)

Parâmetro	Medida (mm)		Medida (mm)		Diferença média entre os métodos (mm)	Desvio padrão (mm)	Valor de *p*
	Modelos de gesso N = 15		Modelos digitais N = 15				
	Média	DP	**Média**	DP			
DMD 16	9,5167	0,4649	9,4767	0,6585	0,0400	0,3702	0,6820
DMD 15	6,3480	0,4734	6,2253	0,5278	0,1227	0,1283	**0,0020**
DMD 14	6,8507	0,4570	6,7553	0,5017	0,0953	0,1039	**0,0030**
DMD 13	7,5653	0,4529	7,3813	0,5567	0,1840	0,1925	**0,0020**
DMD 12	6,2187	0,5173	6,0753	0,6338	0,1433	0,3204	0,1050
DMD 11	8,3173	0,4826	8,1840	0,5044	0,1333	0,1564	**0,0050**
DMD 41	5,2387	0,3415	5,1367	0,3636	0,1020	0,1387	**0,0130**
DMD 42	5,6407	0,3917	5,4760	0,4853	0,1647	0,1785	**0,0030**
DMD 43	6,3740	0,4377	6,3453	0,5837	0,0287	0,3478	0,7540
DMD 44	6,8553	0,4121	6,8100	0,4453	0,0453	0,1458	0,2490
DMD 45	6,8560	0,3458	6,8187	0,4206	0,0373	0,1518	0,3570
DMD 46	10,6913	0,6317	10,5707	0,7322	0,1207	0,3294	0,1780
ALT 16	6,7220	0,7568	6,6473	0,8863	0,0747	0,2806	0,3200
ALT 14	8,0333	0,9380	8,0773	1,0241	-0,0440	0,3190	0,6020
ALT 13	9,2660	0,8620	9,2507	0,8666	0,0153	0,1480	0,6940
ALT 11	9,5953	1,1928	9,6147	1,0571	-0,0193	0,2077	0,7240
ALT 41	8,0347	0,8045	8,1253	0,7752	-0,0907	0,1134	**0,0080**
ALT 43	9,3567	1,1051	9,4100	1,0914	-0,0533	0,1302	0,1350
ALT 44	8,0753	0,9934	8,0813	0,9086	-0,0060	0,2349	0,9230
ALT 46	6,7833	0,7321	6,9033	0,8980	-0,1200	0,2870	0,1280
DIC sup	33,0240	2,4095	32,6907	2,4493	0,3333	0,4906	**0,0200**
DIC inf	24,5120	2,1650	24,5853	2,1964	-0,0733	0,5915	0,6390
DIM sup	49,3787	3,6017	49,2227	3,5019	0,1560	0,2964	0,0610
DIM inf	43,3540	2,7334	43,0673	2,6327	0,2867	0,5070	**0,0460**
Overjet	2,5493	0,8189	2,5287	0,6563	0,0207	0,5006	0,8750
Overbite	2,8613	1,1676	2,4013	0,9835	0,4600	0,4669	**0,0020**
Rel sag dir 2	21,7413	2,0252	21,9413	2,0864	-0,2000	0,7975	0,3480

ANEXO N - Artigo 3 – Comparação entre modelos de gesso e modelos digitais por escaneamento do modelo de gesso (3Shape) medido no programa Ortho Analyzer (examinador 2)

Parâmetro	Medida (mm)		Medida (mm)		Diferença média entre os métodos (mm)	Desvio padrão (mm)	Valor de *p*
	Modelos de gesso N = 15		Modelos digitais N = 15				
	Média	DP	**Média**	DP			
DMD 16	9,5167	0,4649	9,3740	0,5880	0,1427	0,5189	0,3050
DMD 15	6,3480	0,4734	6,3187	0,5275	0,0293	0,2519	0,6590
DMD 14	6,8507	0,4570	6,7960	0,5663	0,0547	0,1992	0,3060
DMD 13	7,5653	0,4529	7,4387	0,6236	0,1267	0,2862	0,1090
DMD 12	6,2187	0,5173	6,0673	0,6184	0,1513	0,2744	0,0510
DMD 11	8,3173	0,4826	8,2293	0,5214	0,0880	0,2253	0,1530
DMD 41	5,2387	0,3415	5,1100	0,4142	0,1287	0,2324	0,0500
DMD 42	5,6407	0,3917	5,5720	0,4687	0,0687	0,1642	0,1280
DMD 43	6,3740	0,4377	6,3953	0,6173	-0,0213	0,3702	0,8270
DMD 44	6,8553	0,4121	6,8100	0,4393	0,0453	0,1935	0,3800
DMD 45	6,8560	0,3458	6,8980	0,4334	-0,0420	0,2106	0,4530
DMD 46	10,6913	0,6317	10,5420	0,6274	0,1493	0,1916	**0,0090**
ALT 16	6,7220	0,7568	6,6507	0,9140	0,0713	0,3569	0,4520
ALT 14	8,0333	0,9380	7,9693	1,0626	0,0640	0,3510	0,4920
ALT 13	9,2660	0,8620	9,1807	0,8891	0,0853	0,1710	0,0740
ALT 11	9,5953	1,1928	9,6100	1,0875	-0,0147	0,2238	0,8030
ALT 41	8,0347	0,8045	8,0520	0,9191	-0,0173	0,1770	0,7100
ALT 43	9,3567	1,1051	9,2907	1,1068	0,0660	0,2181	0,2610
ALT 44	8,0753	0,9934	7,8573	0,9754	0,2180	0,2633	**0,0060**
ALT 46	6,7833	0,7321	6,6600	0,8461	0,1233	0,2120	**0,0410**
DIC sup	33,0240	2,4095	32,8967	2,2851	0,1273	0,4489	0,2900
DIC inf	24,5120	2,1650	24,6027	2,1546	-0,0907	0,6062	0,5720
DIM sup	49,3787	3,6017	49,1933	3,4314	0,1853	0,6247	0,2700
DIM inf	43,3540	2,7334	43,3947	2,4840	-0,0407	0,6053	0,7990
Overjet	2,5493	0,8189	2,6793	0,8322	-0,1300	0,6032	0,4180
Overbite	2,8613	1,1676	2,3167	0,9199	0,5447	0,4589	**0,0000**
Rel sag dir 2	21,7413	2,0252	21,8787	2,0018	-0,1373	0,7675	0,5000

ANEXO O - Artigo 3 – Comparação entre modelos de gesso e modelos digitais por escaneamento do modelo de gesso (OrthoProof) medido no programa Digimodel (examinador 2)

Parâmetro	Medida (mm)		Medida (mm)		Diferença média entre os métodos (mm)	Desvio padrão (mm)	Valor de *p*
	Modelos de gesso N = 15		Modelos digitais N = 15				
	Média	DP	**Média**	DP			
DMD 16	9,5167	0,4649	9,5007	0,6047	0,0160	0,2710	0,8220
DMD 15	6,3480	0,4734	6,2727	0,4372	0,0753	0,2171	0,2000
DMD 14	6,8507	0,4570	6,7207	0,4546	0,1300	0,1211	**0,0010**
DMD 13	7,5653	0,4529	7,3840	0,6117	0,1813	0,2669	**0,0200**
DMD 12	6,2187	0,5173	6,1300	0,5831	0,0887	0,1197	**0,0120**
DMD 11	8,3173	0,4826	8,3527	0,5367	-0,0353	0,1612	0,4100
DMD 41	5,2387	0,3415	5,1187	0,3554	0,1200	0,1272	**0,0030**
DMD 42	5,6407	0,3917	5,5560	0,4733	0,0847	0,1606	0,0610
DMD 43	6,3740	0,4377	6,3080	0,5902	0,0660	0,4002	0,5330
DMD 44	6,8553	0,4121	6,6173	0,4163	0,2380	0,1714	**0,0000**
DMD 45	6,8560	0,3458	6,6620	0,3904	0,1940	0,2096	**0,0030**
DMD 46	10,6913	0,6317	10,3327	0,6812	0,3587	0,2298	**0,0000**
ALT 16	6,7220	0,7568	6,5407	0,8404	0,1813	0,2456	**0,0130**
ALT 14	8,0333	0,9380	8,0700	0,9429	-0,0367	0,2462	0,5730
ALT 13	9,2660	0,8620	9,1913	0,8516	0,0747	0,1575	0,0880
ALT 11	9,5953	1,1928	9,6487	1,1387	-0,0533	0,1848	0,2820
ALT 41	8,0347	0,8045	8,0393	0,8787	-0,0047	0,2070	0,9320
ALT 43	9,3567	1,1051	9,3813	1,1089	-0,0247	0,2171	0,6670
ALT 44	8,0753	0,9934	8,1220	0,9992	-0,0467	0,2860	0,5380
ALT 46	6,7833	0,7321	6,9980	0,7901	-0,2147	0,2777	**0,0100**
DIC sup	33,0240	2,4095	32,5033	2,1199	0,5207	0,8118	**0,0260**
DIC inf	24,5120	2,1650	24,4693	2,1013	0,0427	0,5857	0,7820
DIM sup	49,3787	3,6017	49,0987	3,3798	0,2800	0,4284	**0,0240**
DIM inf	43,3540	2,7334	43,3400	2,4608	0,0140	0,6551	0,9350
Overjet	2,5493	0,8189	2,6453	0,8287	-0,0960	0,6471	0,5750
Overbite	2,8613	1,1676	2,3467	1,0341	0,5147	0,6398	**0,0080**
Rel sag dir 2	21,7413	2,0252	21,9613	1,8705	-0,2200	0,7200	0,2560

ANEXO P - Artigo 3 – Comparação entre modelos de gesso e modelos digitais por escaneamento do modelo de gesso (OrthoProof) medido no programa Ortho Analyzer (examinador 2)

Parâmetro	Medida (mm)		Medida (mm)		Diferença média entre os métodos (mm)	Desvio padrão (mm)	Valor de *p*
	Modelos de gesso N = 15		Modelos digitais N = 15				
	Média	DP	**Média**	DP			
DMD 16	9,5167	0,4649	9,4067	0,4784	0,1100	0,2776	0,1470
DMD 15	6,3480	0,4734	6,3087	0,5495	0,0393	0,1556	0,3440
DMD 14	6,8507	0,4570	6,8513	0,5174	-0,0007	0,2209	0,9910
DMD 13	7,5653	0,4529	7,5867	0,6197	-0,0213	0,3204	0,8000
DMD 12	6,2187	0,5173	6,1647	0,6306	0,0540	0,3468	0,5560
DMD 11	8,3173	0,4826	8,3707	0,5024	-0,0533	0,1692	0,2420
DMD 41	5,2387	0,3415	5,2020	0,2716	0,0367	0,1931	0,4740
DMD 42	5,6407	0,3917	5,5727	0,4602	0,0680	0,2107	0,2320
DMD 43	6,3740	0,4377	6,4533	0,4771	-0,0793	0,3323	0,3710
DMD 44	6,8553	0,4121	6,8620	0,5067	-0,0067	0,2565	0,9210
DMD 45	6,8560	0,3458	6,7673	0,4697	0,0887	0,2520	0,1940
DMD 46	10,6913	0,6317	10,4267	0,6961	0,2647	0,2207	**0,0000**
ALT 16	6,7220	0,7568	6,4593	0,7612	0,2627	0,2787	**0,0030**
ALT 14	8,0333	0,9380	7,8273	0,8549	0,2060	0,2553	**0,0070**
ALT 13	9,2660	0,8620	9,1060	0,8680	0,1600	0,1929	**0,0060**
ALT 11	9,5953	1,1928	9,5653	1,1479	0,0300	0,1767	0,5210
ALT 41	8,0347	0,8045	7,9773	0,8233	0,0573	0,1389	0,1320
ALT 43	9,3567	1,1051	9,1853	1,2606	0,1713	0,3162	0,0540
ALT 44	8,0753	0,9934	7,9693	1,0030	0,1060	0,1917	0,0500
ALT 46	6,7833	0,7321	6,5927	0,7495	0,1907	0,1636	**0,0000**
DIC sup	33,0240	2,4095	32,7700	2,2571	0,2540	0,6632	0,1600
DIC inf	24,5120	2,1650	24,5293	1,8978	-0,0173	0,6190	0,9150
DIM sup	49,3787	3,6017	49,0200	3,4514	0,3587	0,5238	**0,0190**
DIM inf	43,3540	2,7334	43,4920	2,6018	-0,1380	0,8501	0,5400
Overjet	2,5493	0,8189	2,5027	0,6735	0,0467	0,5129	0,7300
Overbite	2,8613	1,1676	2,3460	1,0658	0,5153	0,5465	**0,0030**
Rel sag dir 2	21,7413	2,0252	21,7187	2,0089	0,0227	0,8086	0,9150