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Trabalho de Conclusão de Curso

Fluxo digital e criação de banco de dados de modelos anatômicos auriculares para reabilitação protética

Rafael Horta Chagas

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Trabalho de Conclusão de Curso apresentado ao Departamento de Odontologia da Faculdade de Ciências da Saúde da Universidade de Brasília, como requisito parcial para a conclusão do curso de Graduação em Odontologia.

Orientadora: Prof.ª Dra. Aline Úrsula Rocha Fernandes

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Data da defesa: 16 de junho de 2023

Banca examinadora:

_____

Profa. Dra. Aline Úrsula Rocha Fernandes (Orientadora)

_____

Prof. Dr. Rodrigo Antonio de Medeiros (Membro Titular)

_____

Prof. Dr. Tiago Araújo Coelho de Souza (Membro Titular)

_____

Prof. Dr. Paulo Tadeu de Souza Figueiredo
(Suplente)

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RESUMO

O objetivo desse estudo foi registrar o fluxo digital a partir da aquisição de imagens por fotogrametria, até a obtenção dos modelos protéticos digitais de formatos de pavilhão auricular externo, com criação de banco de dados dos modelos digitais. O projeto foi submetido ao CEP/FS/UnB (CAAE 49323921.2.0000.5558). Foram selecionados 6 voluntários, segundo critérios de seleção, os quais foram submetidos à técnica de fotogrametria, que consistiu na execução de 60 fotografias da área de interesse, feitas a partir de ângulos diferentes, por meio de um aparelho celular (Samsung Galaxy J7 Prime. Samsung, Coréia do Sul). As imagens foram processadas pelo software Blender em conjunto com o Addon OrtogonBlender. Os resultados foram analisados através da comparação qualitativa dos modelos quanto à fidedignidade dimensional com os pavilhões auriculares copiados. Os quesitos avaliados foram a capacidade de manter a forma e dimensões similares aos pavilhões auriculares, e riqueza de detalhes. Quanto ao fluxo digital, foi registrado o tempo de trabalho a partir do registro fotográfico até a obtenção dos modelos digitais e upload dos mesmos no banco de dados. Foram registrados a acessibilidade e origem dos softwares utilizados no fluxo digital estabelecido, e as habilidades exigidas para operar as ferramentas citadas. Seis modelos auriculares digitais distintos foram obtidos. Os modelos digitais obtidos foram considerados aceitáveis e apresentaram suficiente similaridade de detalhes e manutenção das estruturas dimensionais. Os modelos foram armazenados em um banco de dados privado na nuvem. A técnica de fotogrametria e o fluxo digital apresentado demonstraram potencial para obtenção de banco de dados de próteses maxilofaciais, produzindo modelos digitais a partir de um fluxo de trabalho reproduzível e com resultado consistente.

PALAVRAS-CHAVE: Prótese Maxilofacial; Impressão Tridimensional; Desenho Assistido por Computador; Fotogrametria; Anormalidades Maxilofaciais.

ABSTRACT

The aim of this study was to record the digital flow beginning on the acquisition of images by photogrammetry, until obtaining digital prosthetic models of external ear and the creation of a database of digital models. The project was submitted to CEP/FS/UnB (CAAE 49323921.2.0000.5558). Six volunteers were selected, according to selection criteria, who were submitted to the photogrammetry technique, which consisted of taking 60 photographs of the area of interest, taken from different angles, using a cell phone (Samsung Galaxy J7 Prime. Samsung, South Korea). The images were processed by Blender software and the Addon OrtogonBlender. The results were analyzed through a qualitative comparison of the models regarding their dimensional reliability with the copied external ear. The evaluated questions were the ability to keep the shape and dimensions similar to the external ear and richness of details. As for the digital flow, the working time from the photographic record to obtaining the digital models and uploading them to the database was recorded. The accessibility and origin of the software used in the established digital flow were recorded, as well as the skills required to operate the aforementioned tools. Six distinct digital ear models were obtained. The digital models obtained were considered acceptable and presented sufficient similarity of details and maintenance of dimensional structures. The models were stored in a private cloud database. The photogrammetry technique and the digital flow presented demonstrated potential for a maxillofacial prosthesis database, producing digital models from a reproducible workflow and with consistent results.

KEYWORDS: Maxillofacial Prosthesis; Printing, Three-Dimensional; Computer-Aided Design; Photogrammetry; Maxillofacial Abnormalities.

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1 INTRODUÇÃO

A reabilitação protética bucomaxilofacial é importante para pacientes que não possuem parte da anatomia facial, seja por trauma, tratamento de neoplasias ou anomalias congênitas [1]. Um dos maiores desafios no processo de criação de próteses, para este fim, é a execução satisfatória da anatomia e estética da estrutura anatômica em questão. O método analógico de confecção é completamente manual, o que gera um processo que consome extensiva quantidade de tempo para ser finalizado, dependente de materiais de moldagem e escultura, e diversas sessões clínicas e laboratoriais, dependendo, ainda, da habilidade artística do profissional [1]. Quanto maior a demora na manufatura das próteses, maior é o tempo para que o paciente possa reconquistar sua vida social com mais confiança [2].

O método convencional começa com a moldagem da região anatômica a ser reabilitada e anatomia contralateral. A partir do modelo de gesso obtido, o próximo passo é o que exige maior destreza do profissional, a utilização de cera para esculpir a estrutura anatômica ausente, baseando-se em fotos antigas ou na observação da mesma estrutura no lado oposto da face. Essa etapa é especialmente desafiadora quando a estrutura de interesse é a orelha, pois sua anatomia é intrincada e complexa, exigindo que a prótese deva ser compatível e simétrica com a outra orelha ou prótese, trabalho meticuloso e cuidadoso [3]. Um molde de gesso, obtido pela inclusão do padrão em cera da escultura, é preenchido com silicone pigmentado [4].

Existem técnicas que têm o potencial de fabricar próteses de forma mais eficiente e esteticamente realista [1], com uso de tecnologias de design assistido por computador e manufatura assistida por computador (respectivamente, em inglês, "computer-aided design" - CAD e "computer-aided manufacturing" - CAM), são baseadas no uso de softwares específicos que auxiliam nas etapas de planejamento e fabricação da prótese. A maior parte do trabalho é feita digitalmente. Diferente dos procedimentos convencionais, os métodos CAD/CAM, ao se utilizarem de registros de imagem, eliminam a etapa de moldagem e um dos fatores de estresse ao paciente [5].

Em casos nos quais o paciente tem uma das orelhas, é possível usar a tecnologia de CAD para espelhar a orelha existente, criando uma cópia simétrica.

No entanto, se o paciente não tiver nenhuma das orelhas, ou seja, tenha um defeito bilateral, o banco de dados é especialmente importante [6]. A criação de database pode facilitar a adesão e utilização mais consistente dos sistemas CAD/CAM. Isso se deve ao fato de que o acesso a bancos de dados diminui o investimento e simplifica a fase de CAD. Os modelos anatômicos pré-selecionados ainda precisam ser adaptados ao defeito anatômico do paciente, no entanto, esse processo consome menos tempo do que confeccionar uma nova prótese sem modelos 3D previamente digitalizados [7].

Dessa forma, o objetivo deste estudo foi registrar o fluxo digital a partir da aquisição de imagens, através de fotogrametria, até a obtenção dos modelos protéticos digitais de formatos de pavilhão auricular externo e criar um banco de dados digital com exemplares anatômicos de pavilhões auriculares externos.

2 MATERIAIS E MÉTODOS

O projeto foi submetido ao Comitê de Ética de Pesquisa em Seres Humanos da Faculdade de Ciências da Saúde/UnB, processo CAAE 49323921.2.0000.5558 e aprovado pelo parecer n. 4.873.289.

Para a seleção de voluntários, estes foram recrutados dentre as pessoas que tiveram contato inevitável com os pesquisadores durante a pandemia de COVID-19, minimizando a exposição desnecessária de outros indivíduos. Como critérios de inclusão, tivemos: a. indivíduos de todos os gêneros; b. faixa etária de 0 a 70 anos de idade; c. ausência de malformação dos pavilhões auriculares externos; d. candidatos diferentes não poderiam possuir anatomia muito similar às previamente registradas; e. possibilidade de submissão à sessão fotográfica. Como critérios de exclusão, tivemos: a. presença de piercing em dos pavilhões auriculares externos, que gerassem deformações visíveis no modelo tridimensional; b. presença de marcas ou mutilações em um dos pavilhões auriculares externos; c. impossibilidade de submissão à sessão fotográfica.

Durante a seleção de candidatos, foi necessário que houvesse variedade dentre as amostras, de forma que existissem modelos anatômicos diversos que pudessem ser adaptados a diferentes pacientes. As características observadas

foram: lóbulo da orelha (preso ou solto), idade do candidato (jovem: 0 a 19 anos; adulto: 20 a 59 anos; e idoso: 60 anos ou mais), sexo do candidato e espaçamento entre a orelha e o crânio (pavilhão auricular externo próximo ao crânio e com superprojeção). As características anatômicas dos voluntários foram registradas com o intuito da verificação da diversidade anatômica obtida inicialmente para o banco de dados criado.

Dessa forma, os candidatos selecionados, que concordaram em participar da pesquisa, assinaram o termo de consentimento livre e esclarecido e foram submetidos à sessão fotográfica, para captura das imagens das regiões bilaterais auriculares. As imagens foram obtidas em formato JPG, por câmera fotográfica de smartphone (Samsung J7 prime, Samsung, Coréia do Sul), equipado com uma câmera de 13 megapixels. As fotos seguiram protocolo, explicado a seguir, de forma que imagens adequadas fossem obtidas, garantindo o sucesso da transformação de imagens bidimensionais em um objeto tridimensional.

Cada voluntário foi orientado a se sentar em uma cadeira com a postura ereta em um ambiente com iluminação uniforme, desobstruído e sem poluição visual. Todos os adereços, como brincos, chapéus, óculos ou qualquer outro que pudesse interferir com a região de interesse deveriam ser removidos previamente, garantindo a ausência de qualquer distorção que poderia ser causada por elementos no ambiente ou no voluntário [8]. Cada indivíduo deveria ser posicionado com o plano de Frankfurt paralelo ao solo e permanecer imóvel, enquanto o operador fazia o registro fotográfico [8]. Esse registro consistiu em um total de 60 imagens capturadas de forma sequencial, sendo 30 fotos tiradas com a câmera na mesma altura da área de interesse e as outras 30 fotos de um ângulo inferior, com aproximadamente 35° de inclinação ao plano horizontal. Todas as fotos deveriam estar centralizadas e focadas na região anatômica a ser estudada, e as 30 fotos deveriam ser obtidas com similar espaçamento entre elas, sendo ideal 6° de diferença de posicionamento entre cada foto, totalizando 180°, de forma que toda a hemiface fosse registrada.

Os arquivos JPG foram processados no programa Blender 2.91 (Stichting Blender Foundation, Amsterdam; 2018), utilizando-se do Addon OrtogOnBlender [9] para fazer a fotogrametria, gerando um objeto tridimensional da área desejada (Figura 1). O objeto tridimensional em questão foi gerado no formato de STL, estágio em que foi possível manipulá-lo e editá-lo, assim, foram removidas todas as partes desnecessárias, obtendo-se um arquivo com o melhor balanço entre qualidade e economia de espaço virtual. Uma vez obtidos os modelos tridimensionais, foram feitas as exclusões das áreas periféricas às estruturas de interesse. Todos os modelos foram editados de forma que repousassem sobre uma base retangular de 8,5 cm de comprimento, de forma que todos seguissem o mesmo padrão base de impressão (Figura 2). Concluídas essas etapas, o objeto tridimensional (3D) foi armazenado em banco de arquivos virtual.

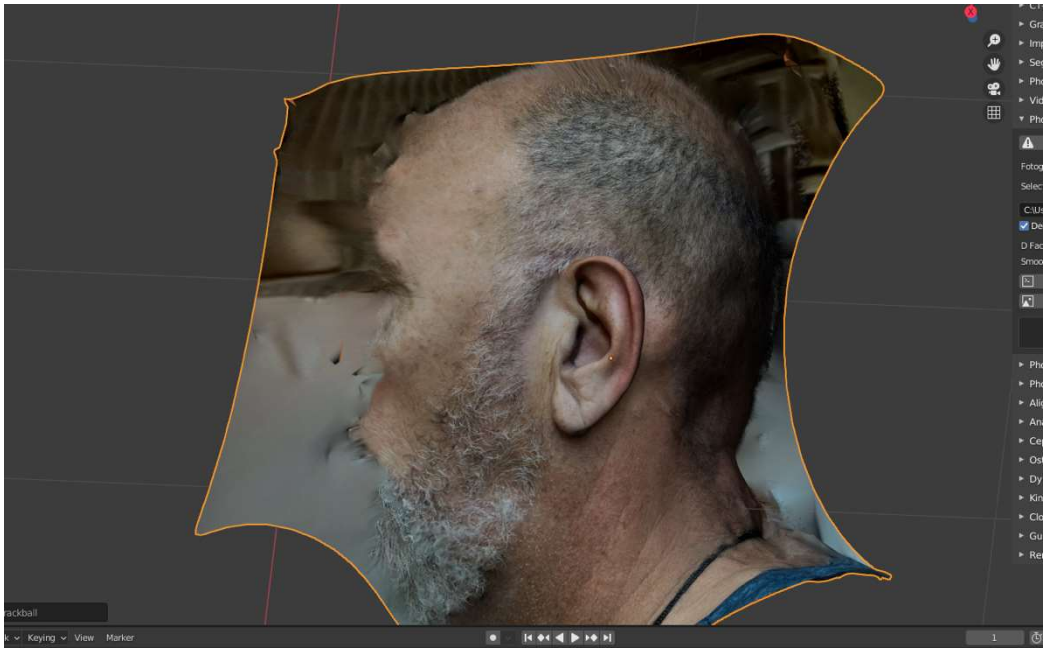

Figura 1 – Imagem tridimensional produzida a partir da fotogrametria (Software: Blender. Addon: Ortog on Blender)

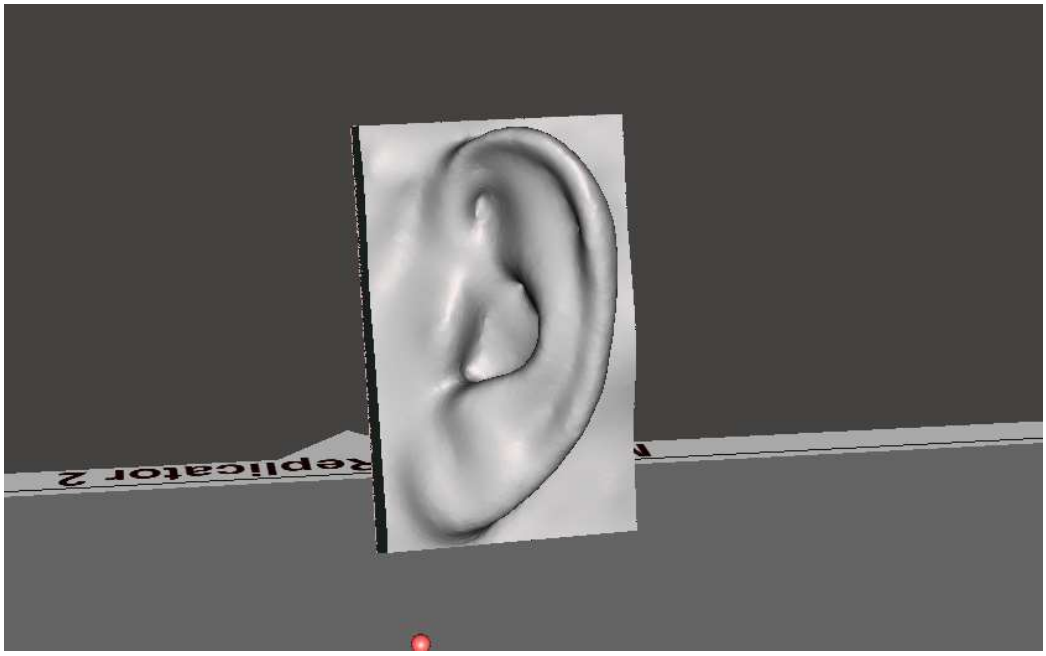

Figura 2 – Objeto 3D finalizado (Software: Autodesk MeshMixer)

Levando em consideração que a impressão tridimensional é muitas vezes o produto final das metodologias CAD/CAM, foi feita a impressão (Phrozen Sonic Mini, Phrozen Technology, Taiwan) de um modelo de estudo em resina de impressão (Quanton Iron Grey, Quanton 3D, Brasil), a partir de um dos modelos tridimensionais obtidos durante a pesquisa. Apesar de a análise de modelos impressos não ser um objetivo do estudo, a impressão do modelo auxiliou na análise da fidelidade do modelo digital, assim como a capacidade de cópia das estruturas de interesse pela metodologia aplicada.

Os modelos digitais obtidos foram comparados com os pavilhões auditivos físicos submetidos à fotogrametria. Os parâmetros utilizados foram a capacidade de manter a forma e dimensões similares aos pavilhões auriculares, além da riqueza de detalhes copiada pela técnica. Os modelos foram considerados aceitáveis caso fosse identificada suficiente qualidade das estruturas copiadas para os modelos digitais para a utilização do fluxo digital, em um cenário clínico de reabilitação protética.

Quanto ao fluxo digital, foi registrado o tempo de trabalho a partir do registro fotográfico até a obtenção dos modelos digitais e upload dos mesmos no banco de dados. Foram registrados a acessibilidade e origem dos softwares utilizados no fluxo digital estabelecido, assim como as habilidades exigidas parar operar as ferramentas citadas.

3 RESULTADOS

Durante o período de aquisição de imagens, 6 voluntáriosforam selecionados e tiveram seus pavilhões auriculares externos fotografados. Para manter maior nível de biossegurança e evitar exposição a interações não essenciais durante o período de quarentena da pandemia, os parâmetros inicialmente propostos foram ignorados e o fator decisivo para a escolha dos voluntários foi a escolha dentre as pessoas que tiveram contato inevitável com os pesquisadores durante a pandemia de COVID-19. Dessa forma os candidatos foram selecionados por meio de uma metodologia de amostragem não probabilistica por conveniência.

As características observadas apresentadas pelos voluntários selecionados foram representadas no Quadro 1.

Quadro 1 – Características observadas no pavilhão auricular externo dos participantes do estudo

Lóbulo da Orelha		Idade			Sexo		Pavilhão auricular	
Solto	Preso	Jovem	Adulto	Idoso	Masculino	Feminino	Próximo ao crânio	Com superprojeção
5	1	1	5	0	3	3	5	1

Para cada modelo auricular, o tempo de todo o processo de obtenção variou entre 2 e 4 horas, sendo que os modelos de menor e maior tempo de desenvolvimento possuíram, respectivamente, 2 horas e 12 minutos e 3 horas e 47 minutos. O tempo necessário para a obtenção variou com a qualidade das fotos obtidas, tempo de processamento do software e preparo dos modelos 3D. Todos os modelos digitais obtidos, após os ajustes finais, foram considerados anatomicamente aceitáveis ao se comparar com as respectivas orelhas originais e, portanto, aplicáveis em tratamento protético restaurador (Figura 3).

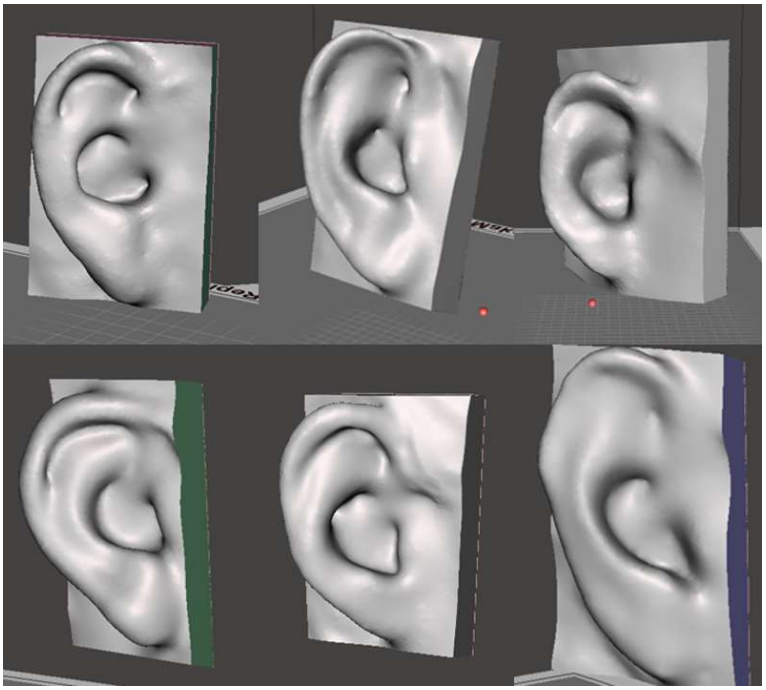

Figura 3 – Versão final de todos os modelos digitais obtidos (Software: Autodesk MeshMixer)

Todos os softwares e metodologias utilizadas na digitalização das estruturas anatômicas e confecção dos modelos digitais tridimensionais foram de código aberto, ou seja, são gratuitos e de livre acesso, estando disponíveis nos sites de seus respectivos desenvolvedores. Também foi possível constatar que apesar de exigir certo conhecimento sobre as ferramentas, a utilização destas não exigiu conhecimento especializado ou grande habilidade manual. Utilizando do modelo impresso em resina de um dos participantes, foi possível confirmar que, de fato, a anatomia deste estava satisfatória e com dimensões equivalentes ao modelo original (Figuras 4, 5,6).

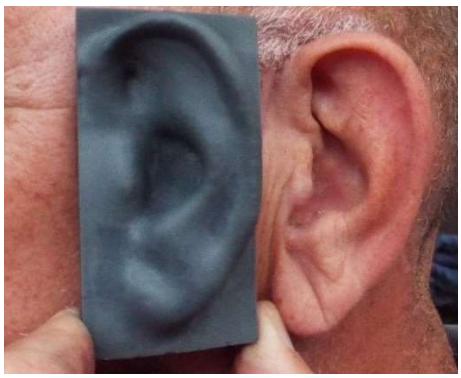

Figura 4 - Modelo em resina (Quanton Iron Grey, Quanton 3D, Brasil) lado a lado com a orelha utilizada para a obtenção das imagens, visão lateral

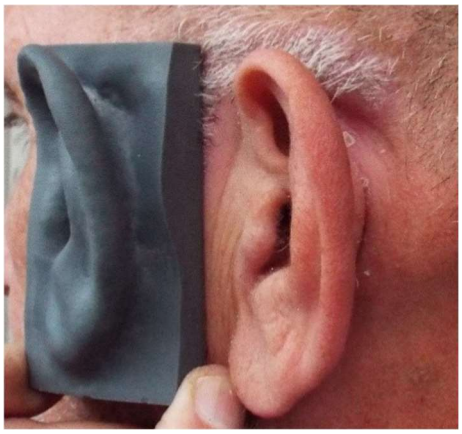

Figura 5 - Modelo em resina (Quanton Iron Grey, Quanton 3D, Brasil), lado a lado, com a orelha utilizada para a obtenção das imagens, visão látero-posterior

Figura 6 - Modelo de orelha, impresso em impressora 3D (Phrozen Sonic Mini, Phrozen Technology, Taiwan) com resina (Quanton Iron Grey, Quanton 3D, Brasil).

4 DISCUSSÃO

Nas técnicas mais modernas de confecção de próteses maxilofaciais, em substituição à moldagem, é obtida uma imagem tridimensional digital do paciente, através de tomografia computadorizada ou fotogrametria, na qual uma grande quantidade de fotos é tirada, seguindo um protocolo, e depois são remontadas em um modelo tridimensional [8]. Com esse molde virtual, que é um objeto tridimensional (3D) mais comumente no formato de STL (*Standard Triangle Language* – Linguagem de triangulos padrão, é uma superfície tridimensional formada por uma malha de triângulos), é possível utilizar softwares e ferramentas de edição específicos para modelar e manipular o modelo, podendo criar uma prótese que possa suprir a demanda do paciente [10]. O processo de modelagem pode ser feito de várias formas, as principais são: a manipulação livre do modelo, de forma que a anatomia é esculpida passo a passo pelo profissional, o uso de

tecnologia de espelhamento, para criar uma cópia invertida da mesma estrutura no lado oposto da face e adaptar essa cópia ao lado defeituoso ou, então, a utilização de um modelo anatômico proveniente de um terceiro, seja de um familiar que se disponha a ter sua anatomia escaneada ou proveniente de um banco de dados, no qual é possível escolher um modelo que pode ser adaptado ao paciente [11].

Após a fase de planejamento finalizada, ou seja, quando o profissional obtiver uma prótese virtual, representada pelo objeto 3D, satisfatória e bem adaptada à anatomia do paciente, o objeto é impresso em uma impressora 3D (Figuras 4, 5, 6). Dependendo do modelo da impressora, é possível realizar a impressão em material biocompatível, imprimindo uma prótese praticamente pronta para uso, ou pode ser impresso um modelo em resina, que será utilizado para criar um molde a ser preenchido por silicone pigmentado, obtendo-se a prótese [11].

O fluxo de produção digital também traz a vantagem de um tratamento menos invasivo e desconfortável para o paciente, além de possivelmente mais rápido. Como já citado anteriormente, a destreza manual e técnica que o operador deve possuir são consideravelmente menores se comparadas com a da produção de modelos de gesso tradicionais, que não podem ser digitalmente redimensionados ou espelhados [12].

Os achados durante o estudo corroboram com a ideia de que as técnicas de confecção de próteses, utilizando recursos digitais, são aplicáveis de forma consistente, utilizando materiais que não são de difícil acesso. Um levantamento de dados recente da FGV – EASP calcula que, em 2020, a população brasileira possuía 424 milhões de dispositivos digitais, dentre os quais estão inclusos smartphones, computadores, tablets e notebooks. Destes, 242 milhões são celulares [13]. Dessa forma, a viabilidade para que o processo digital seja incorporado às reabilitações maxilofaciais, em âmbito público, parece não ser algo inatingível ou de alcance a longo prazo. Com a acessibilidade aos meios digitais e equipamentos pela população, não há impedimento para que a tecnologia também seja cogitada para aprimorar e facilitar as etapas de tratamento.

Os modelos digitais gerados (Figura 3), em sua versão final, possuem entre 5 e 10 MB. Arquivos nessa faixa de tamanho são fáceis de serem armazenados e compartilhados, inclusive por e-mail, uma vez que, em algumas das plataformas mais populares, como Gmail, Yahoo e Outlook, o tamanho combinado máximo de

arquivos é de pelo menos 20 MB. Por sua vez, os serviços de armazenamento populares como Mega (© MEGA, Nova Zelândia), Dropbox (© Dropbox, Inc., Estados Unidos) oferecem entre 2 e 15 GB de armazenamento gratuito, o suficiente para armazenar centenas de modelos digitais.

É importante notar que durante as sessões de fotos foi seguido um protocolo de segurança com o objetivo de proteger tanto os voluntários quanto o pesquisador. Foi obrigatório o uso de máscara de todos os envolvidos, o operador, o qual utilizou luvas e protetor facial ao interagir com os voluntários, adicionalmente, todo o ambiente foi sanitizado com álcool 70° [14]. Para que não fossem prejudicadas as imagens obtidas, o voluntário pôde remover a alça da máscara do lado que foi fotografado e segurá-la em posição, com a utilização de uma luva, reposicionando a alça ao fim da sessão. Nenhum dos voluntários ou pesquisador apresentou recentes, 15 dias antes, de COVID-19. Como consequência das medidas de segurança adotadas e da pandemia de COVID-19, a seleção de voluntários foi severamente prejudicada.

Uma vez que o profissional tem em mãos um modelo digital já pronto, a necessidade de modelar uma nova anatomia em cera deixa de existir. Esse processo geralmente é o mais complexo e demorado. Além de depender que o molde obtido esteja adequado, de forma que não é incomum que a moldagem tenha que ser repetida, a modelagem em cera pode levar diversas sessões laboratoriais para ficar esteticamente agradável, muitas vezes exigindo que o paciente sirva de modelo por longas horas, enquanto são feitos ajustes no padrão de cera. Em contrapartida, o modelo digital, que já conta com a face tridimensional do paciente, é de muito mais fácil ajuste e exige menos do paciente, levando em consideração que a escultura do modelo digital parte de uma anatomia pré-obtida e pode ser modelada livremente a partir desse ponto. O tempo de trabalho do fluxo digital registrado para a obtenção dos modelos digitais não inclui a possível individualização do modelo ou a modelagem digital, que pode ser feita para alterar partes especificas da anatomia do modelo auricular. O tempo registrado para a conclusão do fluxo digital leva apenas em conta o tempo necessário para a integração de um novo modelo para o banco de dados. Levando isso em consideração, é importante saber que em um cenário clínico, é possível que seja necessário mais tempo para a individualização e adaptação do modelo à necessidade pessoal do paciente em questão.

Ainda, é importante enfatizar que, apesar do pequeno quantitativo de participantes do estudo (Quadro 1), será possível obter, por meio das imagens tridimensionais armazenadas em banco de dados, infinitas modificações de suas características, por manipulação digital. Portanto, a quantidade de formatos de pavilhões auriculares externos do banco de dados iniciado na presente pesquisa não se limita aos correspondentes aos seis voluntários, mas abre a possibilidade de criação e adaptação de diversos novos, a partir do desenho computacional. A tecnologia não impõe a necessidade de que centenas de orelhas tenham suas características registradas, para que um banco de dados consistente seja criado, o que facilita também o processo de reabilitação.

Por mais que tenha suas vantagens, a técnica digital, por fotogrametria, não é infalível. O tempo de trabalho calculado incluiu as falhas de processamento e a repetição do protocolo de fotogrametria. Além de ser altamente desafiador fazer a regulação dos ângulos fotográficos de forma manual, a iluminação das fotografias, assim como a distância entre a câmera e a estrutura anatômica são de extrema importância, de forma que variações nestas podem fazer com que o software não tenha sucesso na reconstrução da estrutura. Dessa forma, não é incomum que a tomada fotográfica também tenha que ser refeita, ajustando-se o ângulo, distância e iluminação dos quadros fotográficos. Além disso, por mais que os smartphones sejam comuns no Brasil [13] ainda é recurso com uma alta variação de preço e qualidade que pode afetar o resultado final da técnica de fotogrametria.

A reabilitação bucomaxilofacial tem estado vinculada ao serviço público no Brasil, por meio, principalmente, de projetos de extensão universitária. Apesar da demanda por atendimentos ser alta e as próteses estarem contempladas na relação de procedimentos do SUS, não há comercialização de materiais específicos para o processo analógico das reabilitações no país, havendo necessidade de importação de insumos ou uso de alternativos nacionais, não direcionados ao mesmo fim. A incorporação de fluxo digital, além de tornar o processo de confecção de próteses mais rápido, pode atrair a atenção para a especialidade, por meio das publicações científicas que sempre envolvem a divulgação de novas metodologias. A expectativa para que a prótese bucomaxilofacial receba a devida atenção e incentivo pode ser realizada, por meio da associação com a tecnologia.

5 CONSIDERAÇÕES FINAIS

Com base nas imagens coletadas e nos modelos tridimensionais adquiridos, a proposta de criar um compilado de modelos que poderá ser utilizado para o tratamento de pacientes com defeitos auriculares, através da técnica de fotogrametria, que antecipa a impressão tridimensional auxiliada por computador, foi demonstrada como possível.

A aplicação do fluxo digital registrado apresentou resultados consistentes e satisfatórios, obtendo modelos digitais com suficiente manutenção das características anatômicas e dimensionais, comparativamente, entre os modelos digitais e a anatomia dos pavilhões auriculares dos participantes da presente pesquisa.

CONFLITOS DE INTERESSE

Os autores declaram não haver conflitos de interesse.

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ANEXOS

NORMAS DA REVISTA

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Instructions for
Authors
(Revised
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SCOPE

The *Journal of Prosthodontics* promotes the advanced study, science, and practice of prosthodontics, implant, esthetic, and reconstructive dentistry. It is the official journal of the American College of Prosthodontists, the association that represents the dental specialty of prosthodontics. The *Journal of Prosthodontics* serves both researchers and practicing clinicians by providing a forum for the presentation and discussion of evidence-based prosthodontic research, treatment concepts, techniques, and procedures. The objective of the *Journal of Prosthodontics* is to facilitate the effective worldwide transmission of new and innovative prosthodontic-related research and knowledge. The journal publishes original scientific articles presenting information that isnew and relevant to prosthodontics. Additionally, it publishes reports of innovative techniques and clinical treatments, systematic reviews of topics of interest to the field of prosthodontics, reviews ofnew instrumentation and products, new uses for existing material, digital technology advances related toprosthodontics, instructive clinical reports, editorials, and announcements of importance to the prosthodontic community.

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ARTICLE TYPES ACCEPTED

Article type	Description	Abstract type	References	Figures and Tables (total combined)	Total Word pages *
Original Articles					
Research	Original research, in vivo or in vitro	**Structured**: Purpose, Materials and Methods, Results, Conclusions	No limit	8	10
Clinical report	Report of the presentation, treatment, and follow-up of an individual patient	Non-structured	30	10	10
Technique article	Describes a solution to a particular technical problem in clinical dentistry, in a numbered, step-by-step format	Non-structured	20	10	10
Other types					

Reviews	Systematic reviews preferred, contact the editor prior to submitting a non-systematic review	**Structured**: Purpose, Methods, Results, Conclusions	No limit	7	No limit
Letter to theEditor**	Report original data, discuss published articles, or present hypotheses	None required	15	2	4

*Text only (page count does not include title, references, tables, or figures)

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Upon approval for publication, we will publish the letter in the next available print issue of the *Journal of Prosthodontics*. When written in response to an article published in the *Journal*, we will also give the author of the original article the opportunity to respond. If they choose to do so, we will attempt to publish the letter and response in the same issue.

MANUSCRIPT PREPARATION

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Element	Description
Font	12-point, Times New Roman or 10-point Arial
Line spacing	Double-spaced throughout
Margins	One inch (2.5 cm)
Page size	Letter (8 ½ x 11) inches
Page numbers	Yes; start with the title page as page 1, place on lower right-hand corner
Line numbers	Do not use

Required layout	**Title page**: separate file with complete list of authors, affiliations, and conflict of interest **Main Text file (Research & Reviews)**: Abstract & Keywords, Introduction, Materials& Methods, Results, Discussion, Conclusions, Acknowledgements (*optional*, *must be blinded for review*), References **Main Text file (Clinical Reports/Technique articles**): Abstract, & Keywords, Introduction, Clinical Report (or Technique), Discussion, Conclusion/Summary,Acknowledgements (*optional*, *must be blinded for review*), References **Tables** can be placed at the end of the main text file or uploaded in a separate text file. Each table must be numbered and include a title/brief description. **Figures and Figure Legends** can be placed at the end of the main text file or uploaded
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The title page should contain the following information in the order given:

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2) A running title (abbreviated title), not exceeding 60 letters and spaces
3) Authors' full names and authors' degrees and honorifics (i.e., DDS, MSc, PhD, FACP, etc.)
4) Authors' institutional affiliations including city and state (US authors) or city and country(non-US authors)
5) The name, address, and e-mail address of the author responsible for correspondence aboutthe manuscript
6) If the work has previously been presented, the name, place, and date of meeting(s)
7) If any financial support was received, the grant/contract number, sponsor name, and city,state, and country location must be supplied. The information will be disclosed in the published article.
8) If any author has a conflict of interest, it should be reported. These include, for example,patent, ownership, employment, stock ownership, consultancies, or speaker's fee.

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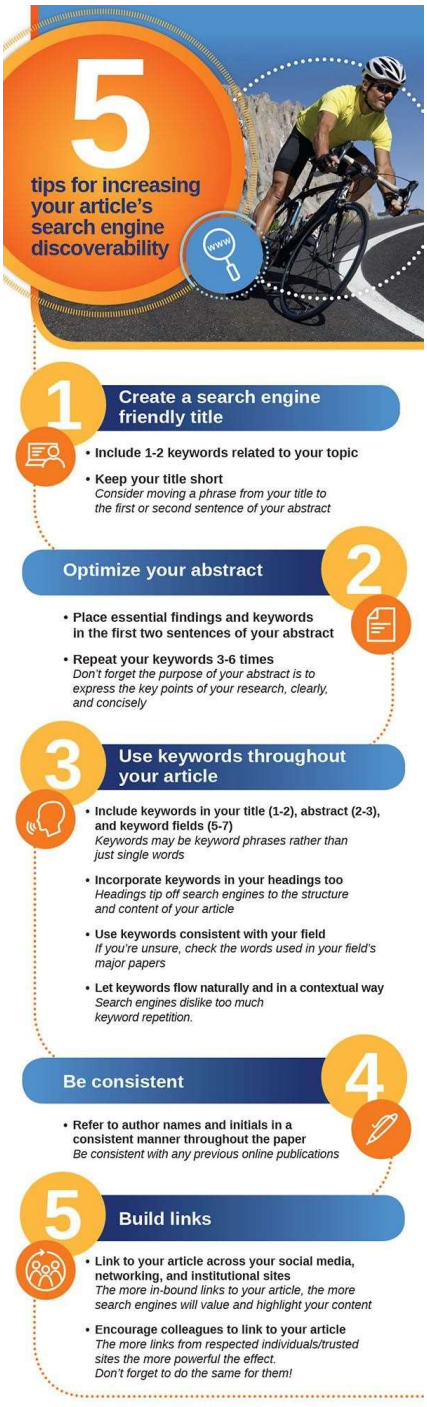

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An abstract is required for all manuscripts, with the exception of letters to the editor, and mustprecede the body of the manuscript. Abbreviations and references should not appear in the abstract. Research manuscripts must conform to the structured abstract format (see

above).
Clinical reports and Technique manuscripts do not need a structured abstract. Following the abstract and on the same page, there should be several words not appearing in the title of the manuscriptto be titled: KEYWORDS.

Text

Research manuscripts should include the following sections: Introduction (no header), Materials andMethods, Results, Discussion, Conclusion, Acknowledgements (optional), and References. Other manuscripts should begin with two to five introductory paragraphs. The remainder of the manuscript should be divided into sections preceded by appropriate headings (i.e., “Clinical report,”“Technique,” etc.).

The ***Introduction*** will include the following: a description of the problem that inspired the study and what distinguishes it from previous research that investigated the same problem; a brief discussion of relevant published material that addressed the same problem or that documents methodology used in the study; and the goal of the study, the purpose statement and null hypothesis.

The ***Materials and Methods*** section describes materials or subjects used and the methods selectedto evaluate them, including information about the overall design, the nature of the sample studied,sample size, the type of interventions (or treatments) applied to the individual elements in the sample, and the principal outcome measure. All human subject research (including surveys) must include a statement of ethical or institutional review board approval in this section.

Statistical methodology and rationale for sample size determination must be included in this section.

Example: A power analysis was conducted to determine the sample size. The World Health Organizationformula was used with 80% power and 0.05 level of significance, and it revealed that 10 specimens per group would be needed to detect the postulated effect size. A total of 120 specimens (40/flexural strength test, 40/impact strength test, and 40/surface roughness and hardness tests) were distributed in two groups.

Gad MM, Fouda SM, Abualsaud R, Aet al. Strength and surface properties of a 3d-printed denture base polymer. J Prosthodont 2021; https://doi.org/10.1111/jopr.13413

Example: The sample size was established using the effect size = 0.25 (medium) or 0.5 (large), a = 0.05, power = 0.8, and number of groups = 3. The results indicated that a total of 159 specimens (medium effect size) or 42 (large effect size) were needed for the fracture loading tests. The analysis showed that 14-53 specimens were needed for each group for the test, and therefore using 15 specimens/group, which

is covered by the results of the G-power calculation, was considered appropriate.

Alberto Jurado C, Kaleinikova Z, Tsujimoto A, et al. Comparison of fracture resistance for chairside cad/cam lithium disilicate crowns and overlays with different designs. J Prosthodont 2021; https://doi.org/10.1111/jopr.13411

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The ***Results*** section will be a clear statement of the findings and an evaluation of their validity based onthe outcome of statistical tests. When reporting results of statistical tests, actual p values must be reported.

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Authors are to use current prosthodontic nomenclature and are referred to the *Glossary of ProsthodonticTerms* (9th Edition) and the *Glossary of Digital Dental Terms* (2nd Edition) for accepted terminology.

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Glossary of Digital Dental Terms, 2nd Edition. J Prosthodont 2021; 30: 172-181.https://doi.org/10.1111/jopr.13439

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Report the actual P values to 3 decimal places. For P values below 0.001 write P<0.001. Report

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μm.Do not italicize foreign words such as "in vivo" or "in vitro"

Use digits for most numbers appearing within the text, except at the start of a sentence, and when the use of the digit places unnecessary emphasis on the number; or when "one" is

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Minimize the use of subheadings in the text.

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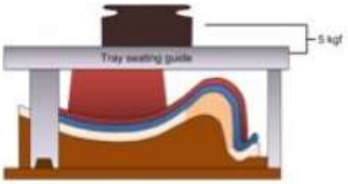
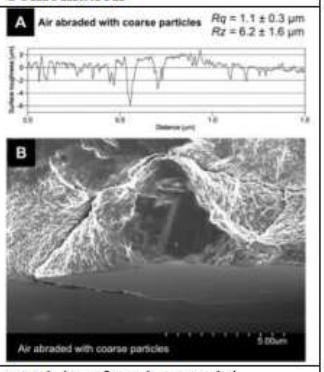
Example			
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MANUSCRIPT SUBMISSION AND REVIEW

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A checklist of manuscript requirements in provided in Appendix B below. This is a helpful guide toreview prior to submitting your manuscript.

Peer review process and reviewer recommendations

All manuscripts will be screened by the editorial office for basic format, language, and submission requirements. Manuscripts are then assessed by the Editor-in-Chief, and, if appropriate, sent to an assistant editor and two or more external reviewers. Manuscripts that are not reviewed will be returned to the authors. Manuscripts will be reviewed for content, originality, importance to the field, appropriateness of statistical analysis, and derivation of conclusions. Authors should note that manuscripts may be returned after initial review by the editorial office if the paper is deemed unlikely to be reviewed favorably by virtue of insufficientinterest for the *Journal of Prosthodontics* readership. This rapid rejection process enables the authorto promptly submit for publication elsewhere. If sent for review, the outcome may be acceptance requests for minor or major revisions, or rejection. Authors are expected to submit revised manuscripts within 90 days. Please contact the editorial office if you are not able to make your deadline.

Submitting a revision

Depending on the number of revisions requested, revisions will be returned to the original reviewers or the editors will conduct the review. New reviewers will be enlisted at the discretion of the editor. Not all revised manuscripts will be accepted. With rare exception, the *Journal of Prosthodontics* will not review more than 3 revisions of the same manuscript.

All changes made in a revised manuscript must be annotated via highlighting or different font color. This will help reviewers locate the changes that correspond with your point-by-point response. **Do not use the Track Changes** feature of Word to mark your changes, as this oftenmakes manuscripts difficult for reviewers and editors to read. Please accept all changes and delete any comments from your manuscripts files before submitting revisions. Please note in your cover letter if the changes are so extensive (i.e., more than 75% of the document) that

it would be unreasonable to annotate the changes.

Responses to reviewers and editors should be included as a text (.doc or .docx) file with themanuscript files and named response to reviewers. A template to use as a guide is provided in Appendix C.

Rebuttals

On rare occasions, editorial decisions may be re-considered. Authors with serious concerns about potential scientific errors in the review process may send a rebuttal letter to the editor. Only written appeals will be considered. Rejected manuscripts may be resubmitted for consideration only with explicit permission of the Editor-in-Chief. In such cases, the submission will be given a newmanuscript number and date of receipt, and will be treated as a new manuscript.

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ETHICAL POLICIES

Data sharing and bioethics

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For original research manuscripts reporting experiments on animals, the corresponding author must confirm that all experiments were performed in accordance with relevant guidelines and regulations. The manuscript must include a statement identifying the institutional and/or licensing committee approving the experiments, including any relevant details regarding animal welfare, patient anonymity, drug side effects, and informed consent.

For experiments involving human subjects, authors must identify the committee (e.g., Institutional Review Board [IRB]) approving the experiments and include with their submission a statement confirming that informed consent was obtained from all subjects. All human studies must adhere to the principles set out in the Declaration of Helsinki (World Medical Association Declaration of Helsinki, published online October 19, 2013. doi:10.1001/jama.2013.281053).

It is the author's responsibility to ensure that a patient's anonymity be carefully protected and to verify that any experimental investigation with human subjects reported in the manuscript

was performed with informed consent and following all the guidelines for experimental investigation with human subjects required by the institution(s) with which all the authors are affiliated. All identifying details (patient names and/or initials and name of specific hospital unit) should be removed from the text, tables, and/or radiographs or other figures. Patients should be assigned numbers instead. Identifying data should be removed from a manuscript unless important clinically or epidemiologically. Clinically and epidemiologically significant details include: race, sex, age, occupation, country or region of origin, and/or sexual orientation. Notethat the same information must be given for each patient or group.

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- The patients are de-identified
- The patients are dead
- There has been a waiver granted by the Institutional Review Board (IRB).

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- U.S. National Institutes of Health Clinical Trials Registry - http://www.clinicaltrials.gov
- EU Clinical Trials Register - https://www.clinicaltrialsregister.eu
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Authors are required to disclose any possible conflicts of interest. These include, for example, patent, ownership, employment, stock ownership, consultancies, speaker's fee. Author's conflict of interest (or information specifying the absence of conflicts of interest) will be included on the title page of published articles.

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1. Substantial contributions to the conception or design or the work; or the acquisition, analysis, or interpretation of data for the work; AND
2. Drafting the work or revising it critically for important intellectual content; AND
3. Final approval of the version to be published; AND
4. Agreement to be accountable for all aspects of the work in ensuring that questionsrelated to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

In addition to being accountable for the parts of the work he or she has done, an author shouldbe able to identify which co-authors are responsible for specific other parts of the work. In addition, authors should have confidence in the integrity of the contributions of their co-authors.

When a large multi-author group has conducted the work, the group ideally should decide who will be an author before the work is started and confirm who is an author before submitting the manuscript for publication. All members of the group named as authors should meet all four criteria for authorship, including approval of the final manuscript, and they should be able to take public responsibility for the work and should have full confidence in the accuracy and integrity of the work of other group authors.

Acquisition of funding, collection of data, or general supervision of the research group alone does not constitute authorship. All persons designated as authors should qualify for authorship, and all those who qualify should be listed. Each author should have participated sufficiently in the work to take public responsibility for appropriate portions of the content.

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- verbatim copying of >100 words of original material in the absence of any citation to the source material, or
- unattributed use of original, published, academic work, such as the structure, argument orhypothesis/idea of another person or group where this is a major part of the new publication and there is evidence that it was not developed independently.

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- verbatim copying of <100 words without indicating that these are a direct quotation from an original work (whether or not the source is cited), unless the text is accepted as widely used or standardized (e.g., the description of a standard technique)
- close copying (not quite verbatim, but changed only slightly from the original) of significant sections (e.g., >100 words) from another work (whether or not that work is cited).

If the editorial board of the *Journal of Prosthodontics* suspects a case of plagiarism, we will first contact the authors for clarification. If the authors are unable to sufficiently explain the potential plagiarism, we reserve the right to inform the authors' institutions and funding agencies. If a published article is suspected of plagiarism, we will take the further step of informing our readers,potentially via retraction of the article.

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APPENDIX B: MANUSCRIPT SUBMISSION CHECKLIST

This submission checklist is provided to help authors in the final stage of submission. Following this checklist should ensure the editorial office does not return your manuscript to you prior to evaluation. A more complete description of each item is provided under the appropriate heading in the Information for Authors document.

Separate documents are submitted in the following order:

(1) title page, include any previous presentation and explanation of any conflicts of interest;

(2) main text file (manuscript without author identifiers and without tracked changes) including a structured or standard abstract, keywords, body of the text, tables, figure legends;

(3) figures;

(4) supplementary files (if necessary)

Title Page

- ☐ Title
- ☐ Running head (abbreviated title) of no more than 60 character spaces
- ☐ Author(s) full name(s) written as First Name then Last Name, and academic degree(s), andthe institutional affiliation(s) of the author(s) at the time of the study. An asterisk after an author's name and a footnote may indicate a change in affiliation. Department,Institution, Locations. (Example: Department of Prosthodontics, University of North Carolina School of Dentistry, Chapel Hill, NC)
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- ☐ Disclosure of financial support, including grant numbers
- ☐ Explanation of any conflicts of interest
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Manuscript Body

- ☐ No line numbers
- ☐ Statement is included in the Materials and Methods section that human experimentation has beenapproved by the local institutional review board or conforms to Helsinki Declaration
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- ☐ Manuscript has been checked by a professional editor or a colleague fluent in English

- ☐ The body of **research manuscripts** includes the Introduction (no heading), Materials and Methods, Results, Discussion, and Conclusions headings
- ☐ The body of **clinical reports and technique manuscripts** includes the Introduction (no heading),

Clinical Report/Technique, Discussion, and Summary headings

Abstract

- ☐ For Original Research Articles, and Review Articles, a structured abstract is included before the body of the manuscript followed by keywords
- ☐ For other manuscripts (e.g., Clinical Reports/Technique articles), include a conventional, unstructured abstract followed by keywords

Style guide

- ☐ Abbreviations: spell out the first time used. Example: Fixed partial dentures (FPDs); can be called “FPD” when used again; avoid abbreviations in the abstract
- ☐ Equipment and/or materials are identified in text by the manufacturer and city and state (US manufacturer) or city and country (non-US manufacturer). Example: (Whip Mix, Louisville, KY); (3Shape, Copenhagen, Denmark)
- ☐ Formatting of reported values, statistical tests conform to *Journal of Prosthodontics* author guidelines

References

- ☐ All references are numbered consecutively in the order they are cited in the text
- ☐ References are Arabic numerals (i.e., 1, 2, 3, etc) in superscript[1]
- ☐ References appear after punctuation marks.[1]
- ☐ All listed references have been cited in the text

Tables

- ☐ Tables are cited in numeric sequence in the text
- ☐ Tables should be submitted in Word

Figures

- ☐ Each figure is numbered with an Arabic numeral and cited in numeric sequence in the text (Fig 1).
- ☐ Photographs of recognizable persons require a signed release from the patient or legalguardian authorizing publication
- ☐ Figures should be submitted in PDF, JPG, EPS, or TIFF format
- ☐ Figures with multiple panels (Fig 1a, 1b) should be submitted as a single file

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- ☐ Informed consent and releases to publish photographs of recognizable persons should be on file with the author and submitted to the editorial office upon request

Revisions

In addition to the above:

- ☐ A highlighted copy should be submitted showing all of the changes made throughout the manuscript; do not use the Word “Track Changes” feature
- ☐ Provide a separate file as a response to the reviewers and editors detailing the changes madeor the changes not made, and why the author chose not to make the changes.

APPENDIX C: RESPONSE TO REVIEWERS TEMPLATE

Use this format to respond to reviewers and editors (the remarks in this template are an example only).

Response to Reviewer 1:

1) *The main findings in this manuscript bear a close similarity to other previously published work and I feel that they add little to the conclusions of that manuscript.*

Response: We respect the comment of the reviewer and appreciate their insight. However, we feel that the previous paper being referred to does differ from our current submission and that the current manuscript adds new data that continues to build upon the programmatic theme of our laboratory. (Discussion of differences in the two works has been redacted to shorten this document) **Text Change:** We have expanded our discussion to reflect these differences, see page 4.

2) *BSPII and osteopontin are well known to be produced by osteoblast-like cells in culture.*

Response: This is true. However, the results have been noted in standard 2D cultures. Very few studies have analyzed the expression of these proteins in 3D cultures as we have submitted. We have previously reported differences in spatial and temporal expression of BSPII in a 3Dmandibular bovine model (Bone 1999). However we did not want to assume that expression in those models would also translate to the aggregate model we describe here.

Text Change: None.

3) *It is not surprising that aggregate Size Correlated to Starting Cell Number, but perhaps "correlated" is the wrong word as there was no rigorous statistical treatment.*

Response: We appreciate the comment and have modified the text accordingly to state the sizewas associated with cultured cell number.

Text Change: Abstract, Results headings page 7 and 8.

Response to Reviewer 2:

1) *Typographic errors warrant author's attention.*

Response: Thank you.

Text Change: Proofread and corrected.