Universidade Federal de Uberlândia

Faculdade de Odontologia

Thaís Cristina Mendes Rodrigues

Avaliação da Adaptação Marginal de próteses implantadas provisórias manufaturadas de forma não digital, fresadas e impressas em 3D.

Marginal fit evaluation of temporary restoration manufactured in a non-digital way, milled and printed in 3D.

Dissertação apresentada à Faculdade de Odontologia da Universidade de Uberlândia, para obtenção do Título de Mestre em Odontologia na Área de Clínica Odontológica Integrada.

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Uberlândia, 2021.

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ATA DE DEFESA - PÓS-GRADUAÇÃO

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

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Aprovada.

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Sumário

RESUMO

O sistema auxiliado por computador (CAD-CAM) permite diferentes técnicas de manufatura. Poucas informações revisadas estão disponíveis sobre o desempenho em relação à adaptação marginal de próteses implantadas provisórias na manufatura fresada, impressa em 3D em comparação com métodos não digitais (convencionais). O objetivo deste estudo in vitro foi avaliar o ajuste marginal de próteses provisórias implanto-suportadas confeccionadas de forma não digital, fresadas e impressas em 3D. Foram realizadas quinze próteses provisórias implanto-suportadas, com três elementos cada uma. Essas amostras foram divididas em três grupos: cinco foram realizadas em laboratório de forma não digital (CG); cinco em sistema fresado (PrograMill PM7, Ivoclar) (GM); e cinco foram impressas com espessura de 50 µm na impressora 3D LCD (Photon S, Anycubic) (GI). As amostras foram obtidas com as seguintes Resinas: Vipicor (VIPI®) na técnica convencional (GI), Telio CAD LT (Ivoclar Vivadent) (GM) e Yller Cosmos Temp (Yller Biomaterials SA) (GI). Não foram realizados processos de acabamento e polimento nas peças, essas foram armazenadas em ambiente seco, protegido da luz externa. A adaptação marginal foi avaliada por meio de imagens de microscópio eletrônico de varredura (MEV), nas faces mesial e distal de cada um dos três elementos das cinco amostras por grupo, resultando (n = 15). Realizado em duas situações : apenas um parafuso central e com todos os parafusos apertados. Os valores de desajuste horizontal foram divididos em: sobreextensão, igual e subextensão. A análise estatística foi realizada por meio do teste de Tukey Kramer, com nível de significância de 5%. Na avaliação vertical e horizontal, as próteses impressas em 3D apresentaram maior desajuste do que as fresadas e o grupo controle (P <0,05). De acordo com as limitações de um estudo in vitro, as próteses impressas em 3D apresentaram os resultados mais desfavoráveis que no método não digital e a forma fresada na avaliação de desajuste vertical e horizontal.

Palavras chaves: impressão em 3D; próteses sobre implantes provisórias; CAD-CAM

ABSTRACT

Computer-aided manufacturing technology (CAD-CAM) allows for different manufacturing techniques. Little revised information is available on the performance in relation to marginal fit in milled manufacturing, 3D printing compared to non-digital methods (conventional). The aim of this in vitro study was to evaluate the marginal fit of implant-supported temporary prostheses that were manufactured in a non- digital way, milled and printed in 3D. Fifteen implant-supported temporary prostheses were produced, with 3 elements each one. The prostheses bridge was divided into three groups: five were performed in the laboratory in a non-digital way (GC); five produced in a milled system (PrograMill PM7, Ivoclar) (GM); and five were printed with thickness of 50 µm on the 3D printer LCD (Photon S, Anycubic) (GI). The samples were produced using de following resins: resin Vipicor (VIPI®) a conventional technique (GI), Telio CAD LT (Ivoclar Vivadent) (GM), Yller Cosmos Temp (Yller Biomaterials SA) (GI). Finishing and polishing processes were not carried out on the pieces and after, were stored in a dry environment, protectingfrom external light. The marginal fit was assessed using a scanning electron microscope images (SEM), resulting (n=15). Performed in 2 situations: only one central screw and with all screws tightened. The horizontal misfit values were divided into over, equal and under extended. Statisticalanalysis was performed using the Tukey Kramer test, with a significance level of 5%. In vertical and horizontal assessment, 3D printed prostheses showed a greater misfit than the milled ones andthe control group ($P<0.05$). According to the limitations of an in vitro study, 3D printed prosthesespresented the most unfavorable results than non-digital method and milled form in the evaluation of vertical and horizontal misfit.

Keywords: 3D printed; implant-supported temporary prostheses; CAD-CAM

INTRODUÇÃO E REFERENCIAL TEÓRICO

Na prática clínica odontológica, experenciamos os benefícios do desenvolvimento de tecnologias digitais. Sendo um dos marcadores desse desenvolvimento a implantação do sistema CAD/CAM -Computer-aided design/Computer aided-manufacturing. (Christensen et al., 2014). Essa tecnologia permitiu a produção de restaurações protéticas por meio de escaneamento e softwares de desenho (CAD) que em um segundo momento permitem criar a restauração, seja por meio de fresadoras ou impressoras digitais em 3D (CAM) (Kapos et al., 2014).

O sistema digital CAD/CAM pode ser dividido em três principais áreas: a aquisição das imagens intraorais, a projeção do modelo virtual e a manufatura da restauração. (Alghazzawi et al., 2016). Esse sistema proporcionou a fabricação de restaurações indiretas e infraestruturas em tempo reduzido através da fresagem do material, conhecida com técnica de manufatura subtrativa. (Kayatt & Neves, 2014). Sendo que essas coroas protéticas fresadas, possuem níveis aceitáveis de adaptação marginal. (Drago (2006) e Neves (2014), além de alcançarem também resistência e estética satisfatórias. (Heintze, 2010; Anunmana, 2014). Todos esses benefícios permitiram que houvesse uma grande aceitação do sistema CAD/CAM na odontologia, o que aumentou consideravelmente a flexibilização na aplicação do fluxo digital aos protocolos clínicos odontológicos. (Kayatt & Neves, 2014; Anadioti, 2014; Kocaağaoğlu, 2017).

A impressão em 3D é outra possível forma de manufatura de restaurações protéticas no fluxo digital, sendo também conhecida como técnica aditiva, pois é um processo de criação que é feito a partir várias camadas que se sobrepõem. (Alcisto J, 2011) A impressão 3D é capaz de produzir menor desperdício, o que poderá levar a uma redução de custo, pois utiliza somente o material necessário, o que reduz a necessidade de armazenamento de matéria-prima além da redução do impacto ambiental. Esses benefícios aumentam as possíveis aplicações das impressoras, principalmente na área da saúde. (Torabi,2015).

A forma de manufatura por meio de impressoras 3D vem ganhando mais espaço nos laboratórios e consultórios odontológicos, por vários motivos, pelas várias possibilidades de criação de dispositivos odontológicos, como guias cirúrgicos, pelas várias opções de marcas, modelos com características diferentes, além da quebra patentes pelos fabricantes da tecnologia. (Van Noort R,2013). Recentemente, muitos estudos vêm avaliando a acurácia de modelos digitais em comparação aos modelos obtidos de forma convencional, obtendo resultados satisfatórios em relação a nova tecnologia. (Kasparova et al., 2013). O que conduz ao questionamento sobre a performance das impressoras em 3D comparada a das fresadoras e a forma convencional na produção de coroas protéticas provisórias.

O assentamento passivo e a adaptação marginal da estrutura protética são aspectos desejados em próteses fixas sobre implantes. Esse assentamento passivo é indispensável para equilibrar os aspectos mecânicos e biológicos, além de reduzir a carga do pilar protético, parafuso e osso circundante. (Abduo J,2014). A ausência desses aspectos pode gerar vários problemas de origem biológica, como a infiltração bacteriana que poderá resultar em periimplantite, dor e inflamação com perda óssea. Além de problemas mecânicos como afrouxamento e fratura de parafusos, risco de fratura da prótese, fratura do componente protético, chegando até a perda da osseointegração. (Skalak, 1983; Resende, 2015).

Portanto, o objetivo desse trabalho foi avaliar e comparar a adaptação marginal de coroas provisórias implantadas de 3 elementos que foram manufaturadas de forma não digital (convencional), fresadas e impressas em 3D.

Marginal fit evaluation of temporary restoration obtained by manufactured in a non-digitalway, milled and printed in 3D

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The authors report no conflicts of interest related to this study.

ABSTRACT

Statement of the problem. Computer-aided manufacturing technology (CAD-CAM) allows for different manufacturing techniques. Little revised information is available on the performance in relation to marginal fit of temporary restoration in milled manufacturing, 3D printing compared to non-digital methods (conventional).

Purpose. The aim of this in vitro study was to evaluate the marginal fit of temporary restoration that were manufactured in a non- digital way, milled and printed in 3D.

Material and Methods. Fifteen temporary restorations were produced, with 3 elements each one, and were divided into 3 groups: non-digital in the laboratory (GC); milled form (GM) and 3D printed (GI). The marginal fit was assessed using a scanning electron microscope images (SEM), resulting (n=15). Performed in 2 situations: only 1 central screw and with all screws tightened. The horizontal misfit values were divided into over, equal and under extended. Statistical analysis was performed using the Tukey Kramer test, with a significance level of 5%.

Results. In vertical and horizontal assessment, 3D printed restorations showed a greater misfit than the milled ones and the control group ($P<0.05$).

Conclusion. 3D printed presented the most unfavorable results than non-digital method and milled form in the evaluation of vertical and horizontal misfit.

Keywords: 3D printed; temporary restoration; CAD-CAM;

CLINICAL IMPLICATIONS

The use of new technologies in the manufacture of temporary restorations can provide agility and efficiency in relation to non-digital methods.

INTRODUCTION

The benefit of digital technologies has made it possible to produce temporary restorations manufactured using milling machines or 3D digital printers (CAM).[1-3] The importance of temporary restorations in an oral rehabilitation is unquestionable so that there is gingival conditioning and the success of the final restoration.[4] The possibility of digital flow can reduce clinical stages and it also makes the results more independent of the operator's technical skills.[5,6] Milled prosthetic restorations have acceptable levels of marginal fit.[7] In addition to also achieving satisfactory resistance and aesthetics.[8] Thus allowing a greater acceptance of the digital flow in dental clinical protocols.[9]

The 3D printing is the additive manufacturing form of digital flow. The American Society for Testing and Materials (ASTM) has defined additive manufacturing (AM) as "a process of joining materials to make objects from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing methodologies".[10,11] This manufacturing technique is capable of producing less waste, which can lead to cost savings, in addition to reducing the need for storage of raw materials, not to mention less environmental impact.[12-15] And also reducing the time of intraoral exposure of patients and the number of consultations.[16-19]

Passive seating and marginal fit of the prosthetic structure are desired aspects in prosthetic restorations.[20-22] These are indispensable to balance the mechanical and biological aspects, in addition to reducing the load on the prosthetic abutment, screw and surrounding bone.[23-25] The absence of these aspects can generate several problems of biological origin, such as bacterial infiltration that can result in peri-implantitis, pain and inflammation with bone loss.[26,27] In addition to mechanical problems such as loosening and fracture of screws, risk of fracture of the prosthetic component, even loss of osseointegration.[28-30] In laboratory studies, the Scanning Electron Microscope (SEM) is a widely used tool for analyzing and measuring restorations misfit.[31-33]

Therefore, the aim of this study was to evaluate the marginal fit and passive seating of temporary restorations that were manufactured in a conventional way, mentioned as non-digital in this study, milled and printed in 3D. The null hypotheses were that there were no difference between the types of restorations and there were no difference between the evaluations with a central screw and with all 3 screws.

MATERIAL AND METHODS

The present study followed a 1x3 factorial design having as main study factor marginal fit in 3 levels: non-digital or conventional (GC), milled group (GM) and 3D printed (GP). The misfit of implant structures over each cast was evaluated using Scanning Electron Microscopy (SEM) (SEM VEGA\TESCAN) (Neves, et al., 2014b).

A typodont (P Oclusal / São Paulo, SP- Brazil) with 3 digital analogues for a fixed implant-supported prosthesis (EFF – dental components, São Paulo, Brazil) from first maxillary left premolar to first maxillary left molar was used as a master cast, simulating a clinical situation of a maxillary posterior partially edentulous (Kennedy class II) (Fig. 1).

For the Control group, 5 fixed implant-supported temporary restoration was fabricated from the master cast, using a conventional technique with acrylic resin (Vipicor,VIPI®) following the manufacturer's instructions. For GM and GO groups, the scan bodies (Healing Scan, EFF Dental – São Paulo, Brasil) were installed in master model a five digital scanner were performed by 3Shape TRIOS (3Shape North America), and the files in. stl that were manipulated restoration design with software (3Shape TRIOS /3Shape North America) (Fig. 2).

Then the samples were produced using de following resins: resin Telio CAD LT (Ivoclar Vivadent) (GM), Yller Cosmos Temp (Yller Biomaterials SA) (GI) and was divided into three groups: five were produced in a milled system (PrograMill PM7, Ivoclar) (Fig. 3), five were printed with thickness of 50 µm on the 3D printer LCD (Photon S, Anycubic) (Fig. 4), and the others were performed in the laboratory in a non-digital way. Finishing and polishing processes were not carried out on the pieces. The samples were stored in a dry environment, protecting from external light. The vertical and horizontal misfit of restoration (Fig. 5) interface were measured using images from the scanning electron microscope (SEM) in both situations, on the first with only the central screw to stabilize the bridge and the second with the three screws tightened with10N torque, as recommended by the manufacturer. The mesial and distal restorations gap was analyzed of each one temporary restoration of each bridge, resulting in fifteen measurements per group evaluated (n = 15).

Statistical analyses were performed with the statistical software R 2.10.1 (The R Foundation for Statistical Computing)[34] with a significance levelof 5%. The data were checked for normality and homogeneity of variance. A logarithmic transformation was necessary for the data to meet the assumptions of parametric analyses. Multiple comparisons were performed using the Tukey Kramer test. The interfaces were evaluated in the vertical and horizontal directions, for both tested situations: central screw and all screws tightened. And in horizontal evaluation, the measures were classified into three possibilities: overextension (over), under extension (under) and equal.[26]

RESULTS

Despite the evaluation on just central screw or with all screws, GI group showed a significantly larger vertical misfit than GM group and GC group ($P<0.05$) (Table 1). In all types of restorations manufacture, the vertical misfit was significantly higher with one screw than with three ($P<0.05$) (Fig.6)

The vertical misfit was segmented to better understand the data and interpret the differences present between the production methods. (Fig.7)

It was observed that all the faces of the implants of the (GM) and (GC) group presented vertical misfit of less than 75µm, in both situations, with a central screw and with three screws (Fig. 8). The GI group, when evaluated with only one central screw, presented 63.3% of the implant faces with misfit greater than 75µm; 33.3% greater than 120 µm,with a maximum of 270.38 µm. When 3 screws were evaluated (GI group), 93.3% of the faces presented gap below 75 µm, with a maximum of 104.34 µm.

GI group showed greater horizontal misfit when they were evaluated with a central screw than when they were evaluated with three screws ($P<0.05$) (Table 2)

Both with a central screw and with three screws, the horizontal misfit was significantly higher in (GI) than (GM) and (GC). In the horizontal evaluation with a central screw, 43.3%, 93.3% and 70.0% of (GM), (GI) and (GC), respectively, presented smaller restoration (under) and 43.3% (GM), 83.3% (GI) and 66.7% (GC) with three screws (Fig. 8).

With a central screw, 56.7%, 6.7% and 16.7% of (GM), (GI) and (GC), respectively, had a larger restoration (over) and with three screws, 56.7% (GM), 0.0% (GI) and 10.0% (GC).

DISCUSSION

The null hypotheses were that there was no difference between the types of temporary restorations and there was no difference between the evaluations with a central screw and wit h all 3 screws was rejected based on the results obtained. When the central screw was adjusted and also in the situation of three tightened screws, (GI) showed a vertical misfit significantly. It is observed that all the faces of (GM) and (GI) ones presented vertical misfit of less than 75 µm. The restorations produced in a 3D printer, when evaluated with only one central screw,showed 63.3% with misfit greater than 75 µm, 33.3% greater than 120 µm, with a maximum of 270.38 µm. When evaluated with 3 screws, 93.3% of the faces presented gap below 75 µm, with a maximum of 104.34 µm. A fact demonstrates that the tightening of the screws promoted a better seating. But it is important to emphasize this classification of measures was carried out with the intention of showing the distribution of results and allowing a better condition to assess the discrepancy between the forms of manufacture in the situation of central or three screws.[26]

When evaluated with a central screw, 43.3%, 93.3% and 70.0% of the faces of the temporary restorations milled, impressed in 3D and non-digital (control), respectively, had a smaller restoration(under). With three screws, these percentages were 43.3%, 83.3% and 66.7%. But the milled manufacturing showed larger restoration (over) in 56.7% with one difficulty incleaning a temporary restoration that has an extension, resulting in biological problems.[26,27]

Assessing misfit in temporary restorations is extremely important, since misfit can cause problems of mechanical or biological origin, the association of these factors can compromise the longevity and success of the treatment.[26-30] Even printed restorations showing a greater discrepancy in the horizontal evaluation, as the restorations are smaller, it becomes a beneficial option for the peri-implant health of the region, which is so important for proper gingival conditioning.

Manufacturing methods milling and 3D printing, which are being studied in dentistry due to its high applicability.[7,9,10] As they were appreciated in the results, the restorations obtained in 3D printers showed more discrepant results, both in vertical and horizontal evaluations. Since the accuracy of the additive manufacturing method can be influenced by material utilized and also, post-processing procedures.[9-12]. The resin used for printing the temporary restorations is compatible with the 3D LCD printer based on SLA technology and the post curing process was followed according to the resin manufacturer's guidelines. In future studies, the same resin could be compared in different printers to assess the performance of the material.

The increased use of 3D printing represents significant progress. As there is a constant attempt to adapt materials, methods and workflows. According to the limitations of an in vitro study. Further studies are needed to evaluate and compare the materials used with the differenttechnologies of 3D printers.

CONCLUSION

The ways and materials of manufacturing of temporary restorations can influence their characteristics in relation to marginal fit, both vertical and horizontal, with a central or three screws. Additive manufacturing presented the most unfavorable results. However, it represents an opportunity to improve processes, economy and agility in clinical practice, when compared to the milled and non-digital methods.

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TABLES

Table 1- Vertical misfit (µm) as a function of the prosthesis production and evaluation.

	Evaluation			
	Central Screw		Three Screws	
	Standart Deviation	Minimum and maximum value	Minimun and maximun value	Minimum and maximum value
(GM)	13.22 (7.64) Ab	(7.46/26.43)	(0.28) Bb	(0.97/ 1.64)
(GI)	110.41 (33.98) Aa	(53.03/136.71)	(14.83) Ba	(3.96/39.83)
(GC)	10.23 (2.34) Ab	(6.46/12.38)	(1.83) Bab	(1.66/ 6.28)

Different letters (uppercase in the horizontal and lowercase in the vertical) indicate statistically significant differences ($p \leq 0.05$). p (prosthesis) <0.0001; p (evaluation) <0.0001; p (interaction) = 0.0141.

Table 2-Horizontal misfit (µm) as a function of the prosthesis production and evaluation.

	Evaluation			
	Central Screw		Three Screws	
	Standart Deviation	Minimum and maximum value	Standart Deviation	Minimum and maximum value
(GM)	20.66 (4.22) Ab	(13.5/ 23.68)	20.37 (4.05) Ab	(13.62/23.68)
(GI)	122.81 (29.61) Aa	(71.96/147.64)	55.35(23.68) Ba	(28.36/84.59)
(GC)	20.97 (9.89) Ab	(9.32/32.87)	15.15 (6.05) Ab	(8.18/22.38)

Distinct letters (uppercase horizontally and lowercase vertically) indicate statistically significant differences ($p \leq 0.05$). p(protesis)<0.0001; p(evaluation)=0.0010; p(interaction)=0.00068.

LEGENDS

Fig. 1. Maxillary typodont with 3 digital analogues for a fixed implant-supported prosthesis (EFF – dental components, São Paulo, Brazil) from first maxillary left premolar to first maxillary left molar.

Fig. 2. Temporary restoration STL project produced in software (3Shape TRIOS /3Shape North America).

Fig. 3. Milling Machine (PrograMill PM7, Ivoclar).

Fig. 4. 3D Printer (Photon S, Anycubic).

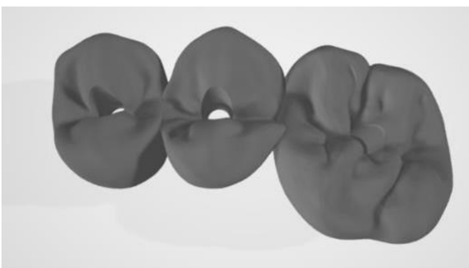
Fig. 5. Schematic showing vertical misfit measurements.

Fig. 6. SEM image, the vertical and horizontal misfit, the vertical misfit was significantly higher with one screw (GI).

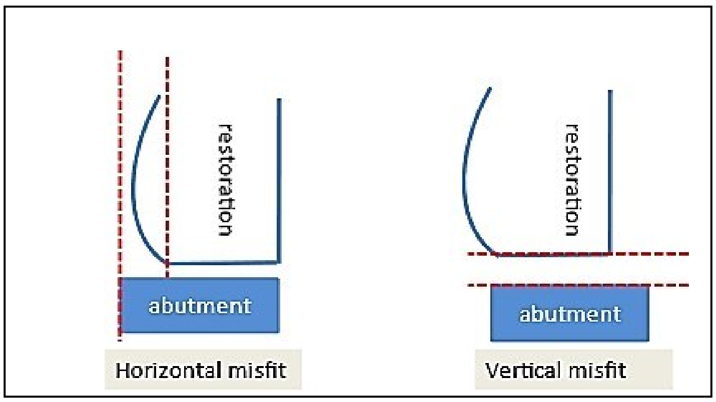
Fig. 7. Classification of vertical misfit, according to the way in which the temporary restorations were obtained and the evaluation performed.

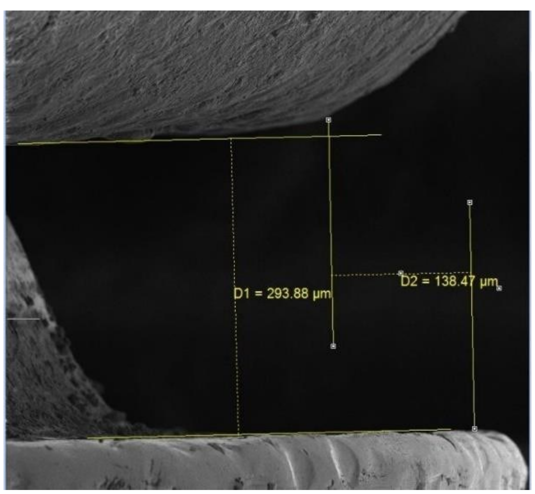
Fig. 8. Classification of horizontal misfit, according to the way of obtaining restorations were obtained and the evaluation performed.

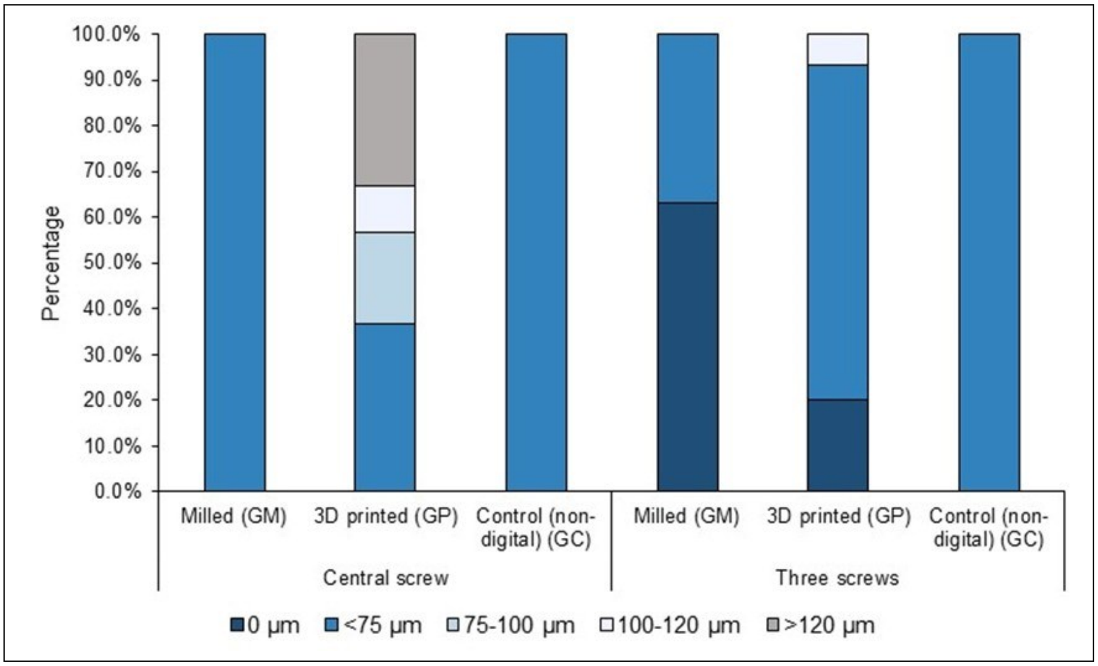
IMAGES




PHOTON


restoration
abutment
Horizontal misfit
restoration
abutment
Vertical misfit


D1 = 293.88 μm
D2 = 138.47 μm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20.0%
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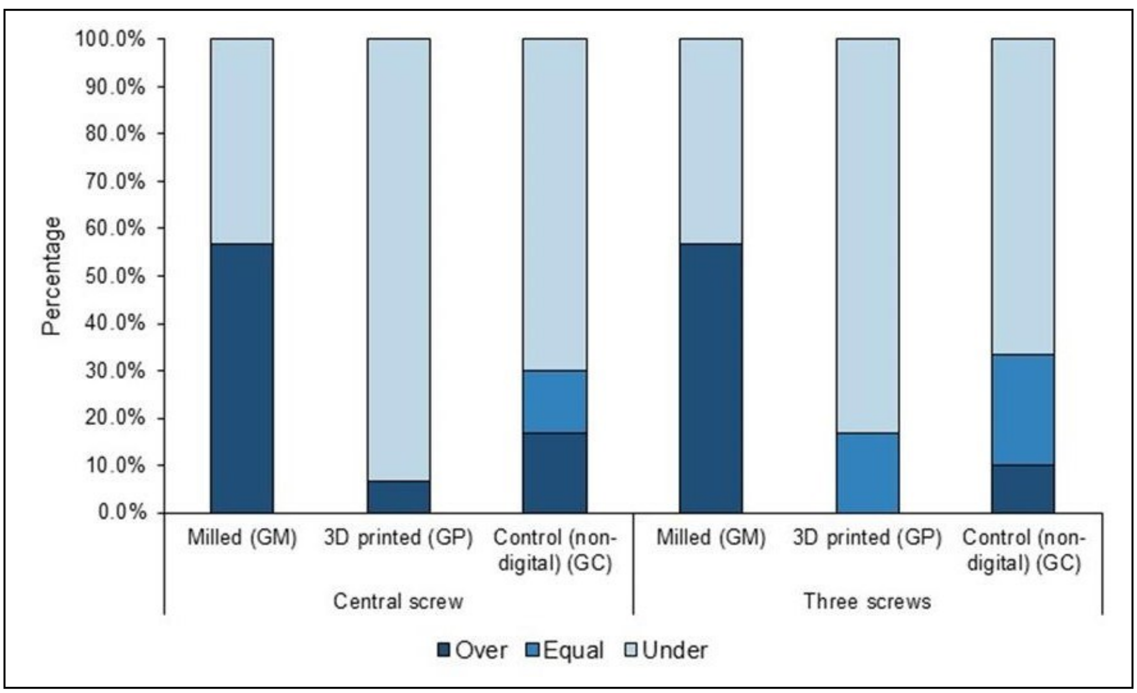
Percentage
Milled (GM)
3D printed (GP)
Control (non-digital) (GC)
Central screw
Three screws
0 µm
<75 µm
75-100 µm
100-120 µm
>120 µm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10.0%
0.0%
Percentage
Milled (GM)
3D printed (GP)
Control (non-digital) (GC)
Central screw
Three screws
Over
Equal
Under