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FACULDADE DE ODONTOLOGIA

ANA VITÓRIA CARVALHO PINTO

ANÁLISE DA ACURÁCIA DE MODELOS E RESTAURAÇÕES PROTÉTICAS SOBRE IMPLANTES OBTIDOS POR TECNOLOGIA CAD/CAM

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Trabalho de conclusão de curso apresentado a Faculdade de Odontologia da UFU, como requisito parcial para obtenção do título de Graduado em Odontologia

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SUMÁRIO

Resumo

Objetivos: Este estudo teve como objetivo avaliar o posicionamento tridimensional de implantes dentários em modelos obtidos por meio de impressões convencionais e digitais.

Material e métodos: Um modelo impresso com três análogos digitais para uma prótese fixa implantossuportada foi usado como modelo mestre. Em cada implante, um corpo de escaneamento para mini pilar foi fixado e escaneado cinco vezes (n = 5) por dois scanners diferentes e todos os arquivos obtidos foram impressos. Uma estrutura metálica de cromo-cobalto foi fabricada sobre o molde mestre, por um sistema CAD / CAM, e posicionada sobre cada modelo (impresso e gesso). A precisão de todos os modelos foi determinada medindo o desajuste vertical e horizontal entre a plataforma da estrutura e o implante usando microscópio eletrônico de varredura (MEV).

Resultados: A avaliação MEV mostrou diferenças estatísticas por desajuste vertical quando todos os parafusos protéticos do implante foram apertados para todos os grupos. Para desajuste horizontal, apenas o grupo de controle apresentou diferenças estatísticas comparando um ou todos os 3 parafusos apertados

Conclusões: Modelos impressos podem ser usados para protocolos de customização de estruturas fresadas sobre implantes.

Clinical Oral Implants Research

Title: Three-dimensional positioning analysis of dental implants in printed casts

Short title: 3D positioning of dental implants in printed casts

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Abstract

Objectives: This study aimed to evaluate the three-dimensional positioning of dental implants in casts obtained by using conventional and digital impressions.

Material and methods: A printed typodont with three digital analogues for a fixed implant-supported prosthesis was used as a master cast. On each implant, a scan body for mini abutment was fixed and scanned five times (n=5) by two different scanners and alll obtained files were printed. One cobalt-chrome metal framework was manufactured over the master cast, by a CAD/CAM system, and positioned over each cast (printed and stone cast). The accuracy of all casts was determined by measuring the vertical and horizontal misfit between the framework platform and the shoulder implant using Scanning electron microscope (SEM).

Results: SEM evaluate shown not statistically differences by vertical misfit when all implant prosthetic screw was tightened for all groups. For horizontal misfit, only the control group showed statistical differences comparing one or all 3 screws tightened

Conclusions: Printed models could be used for customized treatment protocol of milled structures over implants.

MeSH term keywords: Imaging, Three-Dimensional; Dimensional Measurement Accuracy; Dental Implants; Printing, Three-Dimensional; Dental Prosthesis, Implant-Supported

1) INTRODUCTION

Digital technology has been incorporated into dentistry and has shown promising results (de França, Morais, das Neves, Barbosa, 2015). Computer-aided imaging, Computer-Aided Design / Computer-Aided Manufacturing (CAI/ CAD / CAM) is a system that makes possible to obtain restorations and dental casts in a digital manner and has increasingly conquered its space within the different areas in dentistry, including restorative dentistry (Neves, et al., 2014a, das Neves, et al., 2015)

Different digital workflows allow intraoral scanning (IOS) or laboratory scanning processes and are integrated with manufacturing processes through CAD / CAM technologies. Such integration is a great alternative in rehabilitation procedures such as the planning and fabrication of dental crowns and veneers, implant frameworks, printed casts, dental aligners and surgical guides (Buda, Bratos, Sorensen, 2018). In implant-supported rehabilitations, the stone casts still have been traditionally used because it is essential for a customized treatment protocol (Lee, Jung, Wang, Lee, 2019), such as ceramics application, fit check, refine proximal and/or aesthetic adjustments, even when using a digital workflow. If a physical cast is necessary, it can be fabricated by prototyping (printing or milling) the scan data (Lim, Park, Kim, Heo, Myung, 2018).

Adequate implant supported oral rehabilitations depends on accurate reproduction of implants' angulation and position (Papaspyridakos et al, 2014). Although the development of printers machines increased the possibility of a completely digital flow resulting in faster, more comfortable and more predictable procedures (Camardella, de Vasconcellos, Breuning, 2017), there are not enough studies to support the reliability and accuracy of digitally obtained casts for implant supported oral rehabilitations when compared to conventionally obtained casts (Cappare, Sannino, Minoli, Montemezzi, Ferrini, 2019; Alsharbaty, Alikhasi, Zarrati, Shamshiri, 2019).

This study aimed to evaluate the three-dimensional (3D) positioning of dental implants in casts obtained using conventional and digital impressions. The null hypotheses tested was that there would be no differences between implant angulations considering conventional and printed casts.

2) MATERIALS AND METHODS

The present study followed a 2×2x2 factorial design having as main study factors intraoral scanners in 2 levels: Omnicam (CEREC Omnicam v4.5.1; Dentsply Sirona) (CO Group) and TRIOS 3 (TRIOS 3 Dental Desktop v1.6.4.1; 3Shape) (ST group) and casts manufacturing in 2 levels: printed casts and stone cast (Control Group). The misfit of implant structures over each cast was evaluated using Scanning Electron Microscopy (SEM) (ESEM XL-30, Philips Research) (Neves, et al., 2014b).

A printed typodont with three 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 partially edentulous posterior maxillar (Kennedy class II).

2.1) Intraoral scanning: Digital impressions with IOS CO and ST

On each implants of the master cast, scan bodies for mini abutment (EFF – dental components) were fixed with a preload of 10Ncm using a prosthetic wrench (Neodent) and the cast was scanned five times (n=5) with each of the two intraoral scanners (CO group - CEREC Omnicam, Dentsply Sirona, and ST group - TRIOS 3, 3Shape TRIOS, 3Shape North America). All scans were performed by two trained investigators with over five years of experience. The scanning procedure was divided into 3 steps: scanning the occlusal surface, scanning the buccal surface by inclining the scanner tip towards the buccal surface while moving the master cast, and scanning the lingual surface by inclining the scanner tip towards the lingual surface (ARAKIDA et al., 2018; Gedrimiene Adaskevicius, Rutkunas, 2019).

2.2) Casts manufacturing

The stone casts were fabricated through five conventional impressions from the master cast, using a conventional open tray impression technique with splinted transfers (Marghalani, et al., 2018), using light and heavy body polyvinylsiloxane (PVS) (Silagum, DMG, Hamburg, Germany). Five stone casts were obtained (Zero Stone, Dentona, Dortmund, Germany) following the manufacturer’s instructions, using digital analogues.

To print de digital impressions, the files obtained from IOS were exported to Standard tessellation language (STL) using the respective manufacturers’ software (using the highest quality available), and the respective casts were printed using the Zenith D printing machine. (Zenith D, Zenith, Dong-gu, Daegu, Korea), based on stereolithography (SLA), with 50μm layer thickness.

Scan bodies were tightened to the digital analogues on all casts (printed and stone casts) and they were scanned using a laboratory scanner D2000 (3Shape) obtaining .STL files, that were imported into the 3D analysis software program (Geomagic Control X, version 2018.1.1, 3D system) for analysis.

2.3) SEM Evaluation

One cobalt-chrome metal framework was manufactured based on the master cast using a CAD/CAM system (EFF, dental components). This metal framework was positioned over each cast (printed and stone cast) and the accuracy of the casts was determined by measuring the vertical and horizontal misfit between the framework platform and the implant shoulder using SEM with a 400x magnification (ESEM XL-30, Philips Research). Before each analysis, the framework was cleaned by immersion in alcohol for 10 minutes followed by immersion in acetone for 15 minutes, both using an ultrasonic bath, followed by drying using dry nitrogen jets, in order to prevent any debris interference.

The framework was dried and manually attached to the master maxillary cast. The misfit was measured twice: first with only the middle implant prosthetic screw tightened and second: following de 2-1-3 implant sequence for torqueing the screws (Sartori IA, Ribeiro RF, Francischone CE, de Mattos Mda G., 2004). The screws were tightened with a 10 Ncm torque using a prosthetic wrench (Neodent). Six images were obtained for each cast for each of the misfit measurements, corresponding to one mesial and one distal image for each implant.

The vertical and horizontal misfit values were measured. The vertical misfit was determined by measuring the distance between two straight lines drawn tangentially to the abutment and implant platform. The horizontal misfit was quantified by measuring the distance between the lines drawn tangentially between the abutment and the implant. The values were grouped into three categories: underextended, equally extended, and overextended.

2.4) STATISTICAL ANALYSIS

For precision and trueness, data distribution and equality of variances were analyzed using the Shapiro-Wilk and Levene's tests, respectively. Precision was assessed using one-way ANOVA; Trueness was assessed using two-way ANOVA. Both analysis of variance were followed by Tukey's test. All tests were performed with a significance level of 5%.

Vertical and horizontal misfit values did not follow a normal distribution (Kolmogorov-Smirnov test; $p>0.05$). The Kruskal-Wallis test was used to assess statistical significance among the groups, and the Wilcoxon signed rank test was used for post hoc analysis (α = .05). For the purpose of data analysis, the minimum critical value of vertical misfit for final fit was determined to be 16μm (Sartori, et al., 2004). Thus, percentage values higher or lower than 16μm were calculated.

3) RESULTS

Statistical data on the 3D positioning of dental implants was performed in both casts (printed and stone casts).

SEM evaluate shown not statistically differences by vertical misfit when all implant prosthetic screw was tightened for all groups. CO, ST, and stone cast groups presented worst results when only middle implant prosthetic screw tightened compared with all screws tightened (control group). For horizontal misfit, only control group showed statistical differences comparing one or all 3 screws tightened.

4) DISCUSSION

The objective of this in vitro study was to assess the accuracy of the three-dimensional position of dental implants in digital and conventional impressions (stone and printed casts respectively). To the best of the authors' knowledge, this is the first study that used a milled metal framework to measure the marginal misfit level between a framework and casts obtained using different workflows (conventional and digital) by SEM evaluation. The null hypothesisthat no differences in 3D positioning of dental implants would be found between printed and stone casts, was rejected.

The findings of this research showed statistically significant difference between the 3D position of implants considering printed casts obtained from digital impressions and conventional stone casts obtained from conventional open tray impression technique with splinted transfers. Printed casts had higher local deviations than conventional casts. This factor can also be influenced by the scanning technique used and the operator's skill and experience (Resende, et al., 2020).

The prosthesis must be fabricated from an accurate master cast to achieve passive fit and guarantee adequate longevity of implant restorations and fewer risk of biologic and technical complications (Papaspyridakos et al., 2014).Still lacking data from accuracy of printed casts for implant-supported restorations. (Flügge, et al., 2018; Cappare, Sannino, Minoli, Montemezzi, Ferrini, 2019; Alsharbaty, Alikhasi, Zarrati, Shamshiri, 2019; Andriessen, Raijkens, van der Meer, Wismeijer, 2014).

The results of the Scanning Electron Microscopy showed that the printed casts showed greater vertical misfit when only the middle screw was tight, compared to the impression casts, but no significant misfit when all screws were tightened with the torque indicated by the manufacturer. As for horizontal misfit, there were no statistical differences between groups, regardless of how many screws were tightened. Printed casts could be used for the application of ceramics on the milled structure. Because, to apply the ceramic in the metallic infrastructure, the prosthetic must tighten all screws with the torque recommended by the manufacturer.

Although the digital workflow is dominating the market, it still has some deficiencies when compared to the conventional cast which is still considered the gold standard. Previous studies reported that STL file accuracy is comparable to or even superior to the conventional approach, in Kennedy class II scenarios (Chew et al., 2017; Chia et al., 2017; Marghalani et al., 2018). The present study reports the outcomes when the actual STL files are used to print physical casts and mill metal framework to support a 100% digital workflow. Several studies also compared the accuracy of printed implants casts to stone casts for a partial edentulism scenario. Their results also showed that stone casts from the conventional splinted implant impression technique had less 3-D deviations then the printed casts from digital impression technique. (Papaspyridakos et al., 2018; Gedrimiene, et al., 2019; Jang, et al., 2020; Al-Abdullah, Zandparsa, Finkelman, Hirayama, 2013). In digital workflow, there is some limitations that could be identified as influencing factors of accuracy, such as operator technique, master cast undercuts, differences in implants angulation and probably the accumulation of error that were noticed from the IOS stage to the printing stage (Papaspyridakos et al., 2018), even in workflow associated with conventional impressions (Baig, M.R., 2014; Papaspyridakos et al., 2014,2018; Lee, 2019). Nonetheless, as scanners, software and printers evolve and operators become more experienced (Resende et al.; 2020) it will be possible to achieve an accurate result so that the structures can be produced using printed casts. More research is needed to identify the influencing factors.

For single crowns on implants, the use of IOS system and CAD/CAM technology offer the possibility of a digital workflow, is already documented (Lee, Gallucci, 2013). For a full arch implant rehabilitation, a fully digital workflow is not yet fully feasible (Papaspyridakos et al., 2014,2020; Lee, 2019), and maybe, needs a combination of digital and conventional workflow. If a physical cast is necessary, it can be fabricated by prototyping (printing or milling) the scan data (Ender, Mehl, 2013; Ender, Zimmerman, Attin, Mehl, 2016; Patzelt, Emmanoullidi, Stampf, Strub, Att, 2013; Kim et al., 2016; Lim, et al., 2018).This study reveals that in situations with partially edentulous arch, despite the statistical difference in the 3D displacement of the implants in the printed casts, they can still be used for customized treatment protocol of the milled infrastructures. Using this method, a 100% digital workflow for various implant supported prostheses may be used, which until then was not viable and needed a workflow that combined the digital cast with the conventional one. Thus, due to avoidance of impression tray and materials, the digital workflow might offer an increased comfort for patient, and quicker treatment. Furthermore, can also provide to dentist time and cost savings, digital data storage and analysis. (Joda T, Katsoulis J, Brägger U. 2016).

This in vitro study presents some limitations, because the conditions for obtaining conventional and digital impressions are easily controlled in in vitro studies, however the presence of saliva and blood could influence the results. Furthermore, this current study was limited to only one scenario of number of implants, position, and angulation. All of these variables are identified as influencing factors in the accuracy of both conventional and printed casts.

According to the limitations of our study, although the results are statistically different, printed models could be used for customized treatment protocol of milled structures over implants.

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