Dfab

3D FOR PATIENTS

LITERATURE

PEER REVIEWED ARTICLES

J Prosthet Dent. 2023 Apr 25;S0022-3913(23)00186-5. PMID: 37105822
DOI: 10.1016/j.prosdent.2023.03.020

Influence of print orientation on the intaglio surface accuracy (trueness and precision) of tilting stereolithography definitive resin-ceramic crowns

Marta Revilla-León [1], Achara Supaphakorn [2], Abdul B Barmak [3], Vygandas Rutkunas [4], John C Kois [5]

1 Affiliate Assistant Professor, Graduate Prosthodontics, Department of Restorative Dentistry, School of Dentistry, University of Washington, Seattle, Wash; Faculty and Director of Research and Digital Dentistry, Kois Center, Seattle, Wash; and Adjunct Professor, Department of Prosthodontics, School of Dental Medicine, Tufts University, Boston, MA. Electronic address: marta.revilla.leon@gmail.com.
2 Senior Graphic Designer, Kois Center, Seattle, Wash.
3 Assistant Professor, Clinical Research and Biostatistics, Eastman Institute of Oral Health, University of Rochester Medical Center, Rochester, NY.
4 Director, Digitorum Research Center, Vilnius, Lithuania; and Professor, Department of Prosthodontics, Institute of Odontology, Faculty of Medicine, Vilnius University, Vilnius, Lithuania.
5 Director, Kois Center, Seattle, Wash; Affiliate Professor, Graduate in Prosthodontics, Department of Restorative Dentistry, School of Dentistry, University of Washington, Seattle, Wash; and Private Practice, Seattle, Wash.

Abstract

Statement of problem: Vat-polymerization tilting stereolithography (TSLA) technology can be selected for fabricating definitive crowns; however, how the printing variables, including print orientation, influence its manufacturing accuracy remains unclear.

Purpose: The purpose of this in vitro study was to assess the influence of different print orientations (0, 45, 75, or 90 degrees) on the intaglio surface accuracy (trueness and precision) of TSLA definitive resin-ceramic crowns.

Material and methods: The virtual design of an anatomic contour molar crown was obtained in standard tessellation language (STL) file format and used to manufacture all the specimens by using a TSLA printer (DFAB Chairside) and a resin-ceramic material (Irix Max Photoshade single-use cartridges). Four groups were created depending on the print orientation used to manufacture the specimens: 0- (Group 0), 45- (Group 45), 70- (Group 75), and 90-degree (Group 90) print orientation (n=30). Each specimen was digitized by using a laboratory scanner (T710) according to the manufacturer's scanning protocol. The reference STL file was used as a control to measure the volumetric discrepancies of the intaglio surface with the digitized specimens by using the root mean square (RMS) error calculation. The trueness data were analyzed by using 1-way ANOVA followed by post hoc pairwise multiple comparison Tukey tests, and precision data were analyzed using the Levene test (α=.05).

Results: Significant mean trueness (P<.001) and precision (P<.001) value discrepancies were found among the groups tested. Additionally, all the groups were significantly different from each other (P<.001), except for the 45- and 90-degree groups (P=.868). Group 0 showed the best mean trueness and precision values, while the Group 90 demonstrated the lowest mean trueness and precision values.

Conclusions: The print orientations tested influenced the intaglio surface trueness and precision values of the TSLA definitive resin-ceramic crowns.

J Contemp Dent Pract. 2021 Sep 1;22(9):985-990. PMID: 35000940

Fracture Resistance of Three-unit Fixed Dental Prostheses Fabricated with Milled and 3D Printed Composite-based Materials

Karim Corbani[1] Louis Hardan[2] Rita Eid[3] Hasan Skienhe[3] Nawal Alharbi[4] Mutlu Ozcan[5] Ziad Salameh [6]

1 Department of Esthetic and Restorative Dentistry, Faculty of Dental Medicine, Saint Joseph University, Beirut, Lebanon; Doctoral School of Science and Technology, Lebanese University, Hadath, Lebanon, Phone: +961-3-377797, e-mail: corbanidental@gmail.com.

2 Department of Esthetic and Restorative Dentistry, Faculty of Dental Medicine, Saint Joseph University, Beirut, Lebanon.

3 Department of Prosthodontics, Faculty of Dental Medicine, Lebanese University, Beirut, Lebanon.

4 Department of Prosthetic Dental Science, School of Dentistry, King Saud University, Riyadh, Kingdom of Saudi Arabia.

5 Division of Dental Biomaterials, University of Zürich, Clinic for Reconstructive Dentistry, Zurich, Switzerland.

6 Research Center, Faculty of Dental Medicine, Lebanese University, Beirut, Lebanon.

Abstract

Aim: To evaluate the fracture resistance of three-unit fixed dental prosthesis (FDP) made of composite, high-density polymers (HDP), fiber-reinforced composite (FRC), and metal-ceramic (MC) using different fabrication methods.

Materials and methods: A typodont model was prepared to receive a three-unit FDP replacing a missing second maxillary premolar. The prepared model was digitally scanned using an intraoral scanner (Trios3, 3Shape, Denmark). In total, 60 FDPs were fabricated and divided into four groups (n = 15) according to the materials and fabrication method: the subtractive method was used for the FRC (Trilor, Bioloren, Italy) and the HDP (Ambarino, Creamed, Germany) groups; the HDP group was monolithic, whereas the FRC group was layered with a nanocomposite (G-aenial Sculpt, GC). The additive method was used for the 3D printed (3DP) nanocomposite (Irix Max, DWS, Italy) and the Cr-Co (Starbond CoS powder 30) infrastructure of the MC groups. The FDPs were adhesively seated on stereolithography (SLA) fabricated dies. All samples were subjected to thermomechanical loading and fracture testing. The data for maximum load (N) to fracture was statistically analyzed with one-way analysis of variance (ANOVA) followed by Games-Howell post hoc test (α = 0.05).

Results: The MC group reported the highest fracture resistance with a statistically significant difference (2390.87 ± 166.28 N) compared to other groups. No significance was noted between 3DP and HDP groups (1360.20 ± 148.15 N and 1312.27 ± 64.40 N, respectively), while the FRC group displayed the lowest value (839.07 ± 54.30 N). The higher frequency of nonrepairable failures was observed in the MC and FRC groups, while HDP and 3DP groups reported a high frequency of repairable failures.

Conclusion: Significant differences were found in fracture resistance between the tested groups. The load-bearing capacity of the composite-based FPDs exceeded the range of maximum chewing forces.

Clinical significance: 3D printed and milled composite-based materials might offer a suitable solution for the fabrication of FPDs.

Keywords: CAD/CAM; Fiber reinforced composite; Fixed dental prosthesis; Fracture resistance; High-density polymers 3D printing.

Int J Comput Dent. 2020;23(3):225-233. ▪ PMID: 32789310

Effect of material thickness on the fracture resistance and failure pattern of 3D-printed composite crowns

Karim Corbani[1] Louis Hardan[2] Hasan Skienhe[3] Mutlu Ozcan[4] Nawal Alharbi[5] Ziad Salameh [6]

1 Department of Esthetic and Restorative Dentistry, Faculty of Dental Medicine, Saint Joseph University, Beirut, Lebanon; Doctoral School of Science and Technology, Lebanese University, Hadath, Lebanon, Phone: +961-3-377797, e-mail: corbanidental@gmail.com.

2 Department of Esthetic and Restorative Dentistry, Faculty of Dental Medicine, Saint Joseph University, Beirut, Lebanon.

3 Department of Prosthodontics, Faculty of Dental Medicine, Lebanese University, Beirut, Lebanon.

4 Division of Dental Biomaterials, University of Zürich, Clinic for Reconstructive Dentistry, Zurich, Switzerland.

5 Department of Prosthetic Dental Science, School of Dentistry, King Saud University, Riyadh, Kingdom of Saudi Arabia.

6 Research Center, Faculty of Dental Medicine, Lebanese University, Beirut, Lebanon.

Abstract

Aim: To evaluate the fracture resistance and failure pattern of 3D-printed and milled composite resin crowns as a function of different material thicknesses.

Materials and methods: Three typodont tooth models were prepared to receive a full coverage composite resin crown with different thicknesses (0.5, 1.0, and 1.5 mm). The prepared master casts were digitally scanned using an intraoral scanner, and the STL files were used to fabricate 60 nanocomposite crowns divided into two groups according to the material thickness (n = 10) and fabrication method: a 3D-printed group (3D) using an SLA printer with nanocomposite, and a milled group (M) using a milling machine and composite blocks. All crowns were adhesively seated on stereolithography (SLA)-fabricated dies. All samples were subjected to thermomechanical loading and fracture testing. The load to fracture [N] was recorded and the failure pattern evaluated. Data were statistically analyzed using a two-way ANOVA followed by a Bonferroni post hoc test. The level of significance was set at $\alpha = 0.05$.

Results: The 3D group showed the highest values for fracture resistance compared with the milled group within the three tested thicknesses ($P < 0.001$). The 3D and M groups presented significantly higher load to fracture for the 1.5-mm thickness (2383.5 ± 188.58 N and 1284.7 ± 77.62 N, respectively) compared with the 1.0-mm thickness (1945.9 ± 65.32 N and 932.1 ± 41.29 N, respectively) and the 0.5-mm thickness, which showed the lowest values in both groups (1345.0 ± 101.15 N and 519.3 ± 32.96 N, respectively). A higher incidence of irreparable fractures was observed for the 1.5-mm thickness.

Conclusion: 3D-printed composite resin crowns showed high fracture resistance at different material thicknesses and can be suggested as a viable solution in conservative dentistry.

Keywords: 3D printing; CAD/CAM; composite crowns; failure pattern; fracture resistance; additive manufacturing.

J Esthet Restor Dent. 2019 Jan;31(1):51-57. PMID: 30367716 Epub 2018 Oct 27 DOI: 10.1111/jerd.12438.

A review on chemical composition, mechanical properties, and manufacturing work flow of additively manufactured current polymers for interim dental restorations

Marta Revilla-León [1 2 3], Matthew J Meyers [1], Amirali Zandinejad [1], Mutlu Özcan [4]

[1] General Dentistry Department, College of Dentistry, Texas A&M University, Dallas, Texas.
[2] School of Dentistry, University of Washington, Seattle, Washington.
[3] Revilla Research Center, Madrid, Spain.
[4] Dental Materials Unit, Center for Dental and Oral Medicine, University of Zürich, Zürich, Switzerland.

Abstract

Objectives: Additive manufacturing (AM) technologies can be used to fabricate 3D-printed interim dental restorations. The aim of this review is to report the manufacturing workflow, its chemical composition, and the mechanical properties that may support their clinical application.

Overview: These new 3D-printing provisional materials are typically composed of monomers based on acrylic esters or filled hybrid material. The most commonly used AM methods to manufacture dental provisional restorations are stereolithography (SLA) and material jetting (MJ) technologies. To the knowledge of the authors, there is no published article that analyzes the chemical composition of these new 3D-printing materials. Because of protocol disparities, technology selected, and parameters of the printers and material used, it is notably difficult to compare mechanical properties results obtained in different studies.

Conclusions: Although there is a growing demand for these high-tech restorations, additional information regarding the chemical composition and mechanical properties of these new provisional printed materials is required.

Clinical significance: Additive manufacturing technologies are a current option to fabricate provisional dental restorations; however, there is very limited information regarding its chemical composition and mechanical properties that may support their clinical application.

Keywords: 3D printing; additive manufacturing technologies; interim restorations; material jetting; stereolithography.

J Prosthodont Res. 2018 Apr;62(2):218-226. Epub 2017 Oct 12. PMID: 29032176
DOI: 10.1016/j.jpor.2017.09.002.

Three-dimensional evaluation of marginal and internal fit of 3D-printed interim restorations fabricated on different finish line designs

Nawal Alharbi [1], Saud Alharbi [2], Vincent M J I Cuijpers [3], Reham B Osman [4], Daniel Wismeijer [5]

[1]Department of Oral Implantology and Prosthetic Dentistry, Academic Centre for Dentistry Amsterdam (ACTA), University of Amsterdam and Vrije Universiteit Amsterdam, Gustav Mahlerlaan 3004, 1081LA Amsterdam, Netherlands; Department of Prosthetic Dental Science, King Saud University, College of Dentistry, Riyadh, Saudi Arabia. Electronic address: nawalmurshed@gmail.com.
[2]Prince Sultan Military Medical City, Riyadh, Saudi Arabia.
[3]Department of Biomaterials, Radboud University Nijmegen Medical Centre, Nijmegen, The Netherlands.
[4]Removable Prosthodontics Department, Faculty of Dentistry, Cairo University, Egypt; Department of Oral Implantology and Prosthetic Dentistry, Academic Centre for Dentistry Amsterdam (ACTA), Universiteit van Amsterdam and Vrije Universiteit Amsterdam, The Netherlands.
[5]Department of Oral Implantology and Prosthetic Dentistry, Academic Centre for Dentistry Amsterdam (ACTA), Universiteit van Amsterdam and Vrije Universiteit Amsterdam, The Netherlands.

Abstract

Purpose To evaluate the influence of fabrication method and finish line design on marginal and internal fit of full-coverage interim restorations.

Methods Four typodont models of maxillary central-incisor were prepared for full-coverage restorations. Four groups were defined; knife-edge (KE), chamfer (C), rounded-shoulder (RS), rounded-shoulder with bevel (RSB). All preparations were digitally scanned. A total of 80 restorations were fabricated; 20 per group (SLA/3D-printed n=10, milled n=10). All restorations were positioned on the master die and scanned using micro-computed tomography. The mean gaps were measured digitally (ImageJ). The results were compared using MANOVA (α=.05).

Results Internal and marginal gaps were significantly influenced by fabrication method (P=.000) and finish-line design (P=.000). 3D-Printed restorations showed statistically significant lower mean gap compared to milled restorations at all points (P=.000). The mean internal gap for 3D-printed restorations were 66, 149, 130, 95µm and for milled restorations were 89, 177, 185, 154µm for KE, C, RS, RSB respectively. The mean absolute marginal discrepancy in 3D-printed restorations were (30, 41, 30, 28µm) and in milled restorations were (56, 54, 52, 38µm) for KE, C, RS, RSB respectively.

Conclusions The fabrication methods showed more of an influence on the fit compared to the effect of the finish-line design in both milled and printed restorations. SLA-printed interim restorations exhibit lower marginal and internal gap than milled restorations. Nonetheless, for both techniques, all values were within the reported values for CAD/CAM restorations. Significance3D-printing can offer an alternative fabrication method comparable to those of milled restorations.

Keywords: 3D-SLA printing; Additive manufacturing; Finish line design; Marginal and internal fit; Micro-CT.

J Prosthet Dent. 2016 Jun;115(6):760-7. PMID: 26803175
DOI: 10.1016/j.prosdent.2015.12.002 Epub 2016 Jan 21.

Effects of build direction on the mechanical properties of 3D-printed complete coverage interim dental restorations

Nawal Alharbi [1], Reham Osman [2], Daniel Wismeijer [3]

1 Doctoral student, Department of Oral Implantology and Prosthetic Dentistry, Academic Centrum for Dentistry Amsterdam (ACTA), University of Amsterdam and Vrije University, Amsterdam, The Netherlands. Electronic address: nawalmurshed@gmail.com.
2 Researcher, Department of Oral Implantology and Prosthetic Dentistry, Academic Centrum for Dentistry Amsterdam (ACTA), University of Amsterdam and Vrije University, Amsterdam, The Netherlands; and Lecturer, Department of Removable Prosthodontics, Faculty of Dentistry, Cairo university, Cairo, Egypt.
3 Professor, Department of Oral Implantology and Prosthetic Dentistry, Academic Centrum for Dentistry Amsterdam (ACTA) University of Amsterdam and Vrije University, Amsterdam, The Netherlands.

Abstract

Statement of problem: The application of 3-dimensional printing technology is emerging in dentistry and is being increasingly used to fabricate dental restorations. To date, scientific evidence is lacking regarding the effect of different factors on the mechanical properties of the printed restorations with the additive manufacturing technique.

Purpose: The purpose of this in vitro study was to evaluate the effect of build direction (layer orientation) on the mechanical properties of a novel 3-dimensionally (3D)-printed dental restorative material.

Material and methods: Based on the printing direction, 2 groups were tested. In the first group (n=20), the specimens were vertically printed with the layers oriented perpendicular to the load direction. In the second group (n=20), the specimens were horizontally printed with the layers oriented parallel to the load direction. All specimens were fabricated using the DW028D 3D-printer. The specimens were loaded with a universal testing machine at a crosshead speed of 1 mm/min with a 10-kN load cell. The test was performed at room temperature (22°C) under dry testing conditions. The compressive strength was calculated for both groups, and the results were compared using the unpaired t test (α=.05).

Results: The mean ±SD compressive strength for the vertically printed specimens was 297 MPa (±34) compared with 257 MPa (±41) for the horizontally printed specimens (P=.002).

Conclusions: Within the limitations of this study, the layer orientation was found to influence the compressive strength of the material. Vertically printed specimens with the layers oriented perpendicular to load direction have improved mechanical properties more than horizontally printed specimens with the layers oriented parallel to load direction.

Int J Prosthodont. 2016 Sep-Oct;29(5):503-10. DOI: 10.11607/ijp.4835. PMID: 27611757

Factors Influencing the Dimensional Accuracy of 3D-Printed Full-Coverage Dental Restorations Using Stereolithography Technology

Nawal Alharbi, BDS, MSc[1,2] Reham B. Osman, BDS, MSc, PhD[3,4] Daniel Wismeijer, DDS, PhD[5]

1 PhD Candidate, Oral Implantology and Prosthetic Dentistry, Academic Center for Dentistry Amsterdam, Universiteit van Amsterdam and Vrije Universiteit Amsterdam, Amsterdam, The Netherlands.
2 Lecturer, Prosthetic Dental Science Department, College of Dentistry, King Saud University, Riyadh, Saudi Arabia.
3 Researcher, Department of Oral Implantology and Prosthetic Dentistry, Academic Center for Dentistry Amsterdam, Universiteit van Amsterdam and Vrije Universiteit Amsterdam, Amsterdam, The Netherlands.
4 Lecturer, Removable Prosthodontics Department, Faculty of Dentistry, Cairo University, Cairo, Egypt.
5 Professor of Oral Implantology and Prosthetic Dentistry, Head of the Department of Oral Implantology and Prosthetic Dentistry, Academic Center for Dentistry Amsterdam, Universiteit van Amsterdam and Vrije Universiteit Amsterdam, Amsterdam, The Netherlands.

Abstract

Purpose: The aim of the present study was to evaluate the effect of the build angle and the support configuration (thick versus thin support) on the dimensional accuracy of 3D-printed full-coverage dental restorations.

Materials and methods: A full-coverage dental crown was digitally designed and 3D-printed using stereolithography-additive manufacturing (SLA-AM) technology. Nine different angles were used during the build process: 90, 120, 135, 150, 180, 210, 225, 240, and 270 degrees. In each angle, the crown was printed using a thin and a thick support type, resulting in 18 specimens. The specimens were digitally scanned using a high resolution optical surface scanner (IScan D104i; Imetric 3D). The dimensional accuracy was evaluated by digital subtraction technique. The 3D digital files of the scanned printed crowns (test model), exported in standard tessellation language (STL) format, were superimposed with the STL file of the designed crown (reference model) using Geomagic Studio 2014 (3D Systems).

Results: The root mean square estimate value and color map results suggest that the build angle and support structure configuration have an influence on the dimensional accuracy of 3D-printed crown restorations. Among the tested angles, the 120-degree build angle showed a minimal deviation of 0.029 mm for thin support and 0.031 mm for thick support, indicating an accurate fit between the test and reference models. Furthermore, the deviation pattern observed in the color map was homogenously distributed and located further away from the critical marginal area.

Conclusions: Within the limitations of this study, the selection of build angle should offer the crown the highest dimensional accuracy and self-supported geometry. This allows for the smallest necessary support surface area and decreases the time needed for finishing and polishing. These properties were mostly observed with a build angle of 120 degrees combined with a thin support type.

POSTER section

Poster presented at the 2nd SIPRO (Italian Prosthodontics Society) National Congress. Florence, February 17-18, 2023 – full text

THE USE OF CHAIRSIDE 3D-PRINTING TECHNOLOGIES TO RESTORE A COMPROMISED PREMOLAR: A CASE REPORT

Badino G, Comba A, Baldi A, Pera F, Scotti N

Dental School Lingotto, Dipartimento di Scienze Chirurgiche, Università degli Studi di Torino

Aim 3D printing technologies are increasingly being used in dentistry, especially for the fabrication of models and artifacts such as surgical templates, splints or templates. More recently, the use of PMMA and composite resins has enabled the fabrication of temporary restorations. The rapid evolution of materials on the one hand and technologies on the other hand have allowed the introduction of hybrid ceramics that can be printed with laser-sintering technology in a short time, so that the clinician can be offered solutions that can be increasingly employed in the daily clinic. The purpose of this case report is to show the morpho-functional restoration of a highly compromised posterior dental element with chairside technique.

Materials and Methods A 64-year-old female patient came to the Restorative Department of the Dental School Lingotto, University of Turin, for post-endodontic reconstruction of first lower right premolar. The clinical examination showed a destructive distal carious lesion with invasion of the supracrestal connective attachment and the residual tooth structure was thin and full of enamel-dentinal cracks. Therefore, an indirect hybrid ceramic adhesive restoration was planned to be performed after surgical crown lengthening. After performing plexic anesthesia, cavity debridment was performed, which confirmed that the distal cavity margin was close to the bone crest. Therefore, a flap was opened with marginal incision and circumferential osteoplasty to reestablish the correct relationships between supporting tissues and cavity margins. The soft tissues are sutured, and the rubber dam is placed. A circumferential matrix is placed, and after application of a two-pass self-etch adhesive system, a build-up with composite resin is performed. Once photopolymerization is completed, the patient is discharged. After 7 days, stitch removal, preparation of 4.4 for an adhesive crown with 1mm deep butt-join margins and 1.5mm occlusal reduction is performed. An intraoral scan (Trios 3) and CAD fabrication of the prosthetic restoration is performed. The stl file is imported to NAUTA software where the procedure for 3D printing is set up, which is done using a hybrid ceramic (IrisMax, DWS) with a D-Fab 3d printer (DWS). At the end of the process, the artifact is cemented using etch-and-rinse adhesive procedure and dual resin cement.

Results The procedure employed allowed the morpho-functional restoration of an extremely compromised tooth element through an all-digital workflow finalized with 3D manufacturing of a state-of-the-art hybrid ceramic. The fitting and anatomical adaptation of the artifact proved to be optimal, mind the color integration still shows defects, such as excessive opacity of the restorative material and an inconspicuous color gradient.

Conclusion 3D printing technologies represent the future of indirect restorative care, ensuring a dizzying evolution of technologies and materials. Already, the method employed has enabled a single appointment management of CAD-CAM flow and the use of highly-filled resin-based materials. Longer follow-ups and clinical studies are now needed to establish the efficacy of these procedures.

POSTER section

Poster presented at the 2nd SIPRO (Italian Prosthodontics Society) National Congress. Florence, February 17-18, 2023 – full text Special Mention for Research in Prosthetics

CAM-TECNIQUE EFFECT ON CEMENT VOLUME AND FATIGUE RESISTANCE OF POLYMER-INFILTRATED CERAMIC NETWORK (PICN) RESTORATIONS

Rolando C, Rossi T, Baldi A, Comba A, Carossa M, Pera F, Alovisi M, Berutti E, Pasqualini D, Scotti N

Dental School Lingotto, Dipartimento di Scienze Chirurgiche, Università degli Studi di Torino

Aim To evaluate the cement volume and fatigue resistance of milled (in lab or chairside) or 3D-printed polymer infiltrated ceramic network restorations. The first null hypothesis was that cement volume and fatigue resistance were not affected by different CAM tecniques.

Materials and Methods An intact upper premolar was selected and was prepared for an overlay restoration: occlusal reduction of 1,5 mm, two interproximal boxes and inclined chamfer margin on buccal and oral surfaces. After being scanned with lab scanner in Hi-Res mode (inEOS X5, Dentsply Sirona) a 3D model was created. To obtain the same specimen shape for all groups it was 3D printed by Solflex 170 HD (VOCO) in light-curing resin (V-Print Model, VOCO) at the highest resolution (layer thickness = 50 micron). All these 3D-printed specimens were scanned by an intraoral scanner (PrimeScan, Dentsply Sirona) and an overlay restoration was designed with a CAD software maintaining equal morphology and thickness. The so-obtained STL file was processed to produce the restoration with three different techniques (n=10 each): 3D-printing (D-FAB, DWS) (G1); milling procedure by a 4-axis chairside-milling machine (MCXL, Dentsply Sirona) (G2); milling procedure by a 5-axis lab-milling machine (DWX 51D, Roland) (G3). The material used for all the restorations was a polymer-infiltrated ceramic network (PICN): for G1 Irix Max (DWS), for G2 and G3 Vita Enamic (Vita). The same adhesive procedures were performed for all groups both on model and on restoration. Then a self-adhesive cement (Panavia SA Cem, Kuraray Noritake) was used. After removing the excess, specimens were cured 20 s on each side with LED lamp. Specimens were scanned using a Micro-CT (SkyScan 1172, Bruker) to measure the cement volume. Then, specimens were submitted to a fatigue protocol (1st step: 5.000 cycles at 200 N, 2nd step: 5.000 cycles at 400 N, 3rd step: 5.000 cycles at 400 N, 4th step: 10.000 at 600 N, 5th step: 10.000 at 800 N) and the number of cycles before the restoration fracture was detected. The volume in mm3 and the number of cycles were collected and statistically analyzed with one-way ANOVA test.

Results The mean cements volume and accelerated fatigue resistance (number of cycles), ±SD, of different groups are displayed in graph 1 and graph 2 respectively. The cement volume was significantly affected by the CAM-technique tested (p=0.00001), with the chairside-milling process showing higher values than 3D-printed and lab-milled ones. On the other hand, the 3Dprinted PICN showed a significantly higher fatigue resistance than lab-milled and chairside-milled specimens. The chairside-milling process was significantly worse than lab-milled one.

Conclusion Based on the obtained results, the 3D-printing process can reflex the indirect preparation design as a 5-axis milling machine does, while a 4-axis one produces an increase in cement layer which seems to affect the fatigue resistance or indirect adhesive PICN restorations. Thus, the initial null hypotheses were rejected.