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CASE REPORT
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New fabrication method using additive manufacturing technologies for the pattern of pressed lithium disilicate onlay restorations

Novo método de fabricação, usando tecnologia aditiva, do padrão de restaurações do tipo onlay em dissilicato de lítio injetado

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ABSTRACT

The digital workflow in dentistry allows for complete digital processing of the restoration starting with the digital impression using an intraoral scanner to until the fabrication of final reconstruction. Recent advances in 3D printing technologies opened new possibilities also for dental technicians through which wax-up and casting procedures in the laboratories could be eliminated. In this clinical report, a technique is described where the pattern was fabricated using additive manufacturing for pressed lithium disilicate onlay restorations.

KEYWORDS

3D printing; Additive manufacturing technologies; Castable printed pattern; Digital dentistry; Direct Light Processing; Lithium disilicate; Polymer printed; Stereolithography.

RESUMO

O fluxo de trabalho digital em odontologia permite o processamento digital completo da restauração começando com a impressão digital usando um scanner intraoral até a fabricação da peça final. Os avanços recentes nas tecnologias de impressão 3D abriram novas possibilidades também para os técnicos em prótese dentária através dos quais os procedimentos de cera e fundição nos laboratórios poderiam ser eliminados. Neste relato de caso clínico, descreve-se uma técnica onde o padrão foi fabricado usando a fabricação de aditivos para restaurações do tipo onlay em dissilicato de lítio injetadas.

PALAVRAS-CHAVE

Impressao 3D; Tecnologias de fabricação de aditivos; Padrões impressos; Odontologia digital; Processamento de luz direta; Dissilicato de lítio; Polímero impresso; Estereolitografia.

INTRODUCTION

Computer aided manufacturing technologies (CAM) are based on milling or additive manufacturing (AM) where in the latter an object is fabricated through layer-by-layer building process [1]. The American Society for Testing and Materials (ASTM) have determined seven AM categories, namely stereolithography (SLA), material jetting (MJ), material extrusion or fused deposition modelling (FDM), binder jetting (BJ), powder bed fusion (PBF), sheet lamination (SL) and direct energy deposition (DEP) [1]. The most common technologies for 3D printing of polymers in the dental field are the SLA, MJ and FDM methods. Among these methods, in the SLA process, liquid photopolymer in a vat is selectively photo-polymerized layer by layer through a laser in order to create a 3D object [2,3]. The DLP technology on the other hand, is very similar to the SLA technology except form the light source as DLP uses a different light source, such as an arc lamp, with a liquid crystal display panel or a deformable mirror device (DMD) [4]. The MJ technology is based on a process where droplets of building material is deposited through hundreds of nozzles and photo-polymerized layer by layer using an ultraviolet light [5]. In the FDM technologies, the 3D printer extrudes a melting plastic filament that has been heated just beyond its melting point and is deposited one layer at a time onto a building platform according to the 3D data supplied to the printer. The heated material sets immediately after being extruded [6].

The rapid evolution of the market has positioned the 3D printing applications on the edge of the latest technologies in many industrial and medical fields. Yet, in dentistry, fairly limited numbers of applications are available and they have not been analyzed through, validated and systematically used for daily basic clinical procedures. The fundamental limitation is due to the restricted variety of biocompatible 3D printed materials approved for clinical dental applications by recognized organizations. However, some polymers could be used instead of wax or other resins for casting or pressing dental restorations and could be printed in conjunction with AM technologies [7-9]. One such example was the fabrication of the 3D pattern of the framework for the fabrication of a removable partial denture [10-12]. However, to the best of our knowledge, AM technologies has not been used to date for the fabrication of pressed ceramics.

In this clinical report, a technique has been described where the pattern was fabricated using AM technologies for pressed lithium disilicate onlay restorations.

OUTLINE OF THE CASE

A 38-year old male patient presented himself with the chief complaint related to a broken tooth. The patient presented healthy oral conditions. During the intraoral examination, fracture of the disto-lingual cusp and occluso-distal resin composite on the mandibular right first molar was noted (Figures 1a-c). The diagnostic radiographs showed root canal treatment (RCT) with periapical lesion and a deep interproximal restoration (Figure 2).

Figures 1 - a) Occlusal view of the intraoral situation with a cusp fracture on the mandibular right first molar, b) Lingual, c) Buccal view of the clinical situation

Figure 2 - Peri-apical radiograph of the mandibular right first molar

In order to evaluate the remaining tooth structure, resin composite restoration was removed. The disto-lingual cusp and the distal marginal border of the tooth were missing but the disto-buccal, mesio-buccal and mesio-lingual cusps presented sufficient thickness and adequate dentin support that did not necessitate cuspal coverage. Furthermore, the gingival floor of the cavity was located at the level of the bone crest. Thus, crown lengthening along with retreatment of the RCT were indicated in order to restore the tooth in a predictable way [13-15]. Two specialists executed both procedures in a private (Figures 3,4). After complete healing, the tooth was restored with a pressed lithium disilicate onlay restoration as follows:

At the first clinical appointment, build up the tooth was accomplished using resin composite (Filtek Supreme XTE A3D, 3M ESPE, St. Paul, USA) in order to seal the canal opening after endodontic treatment and to provide enough support to the weak cusps that did not present dentin support.

Cavity was then prepared for an onlay restoration where the gingival floor of the preparation was located 0.5-1 mm above the gingival margin with 1 mm width and 2 mm isthmus reduction. Interocclusal space of 1.5. mm was provided for the restorative material and sharp internal angles were rounded using a round-ended tapered diamond bur (8845KR.314.021 and 845KR.314.021, Komet Dental, Lemgo, Germany) under continuous water cooling. Margins of the preparation were outside the contact point with the antagonist (Figure 5).

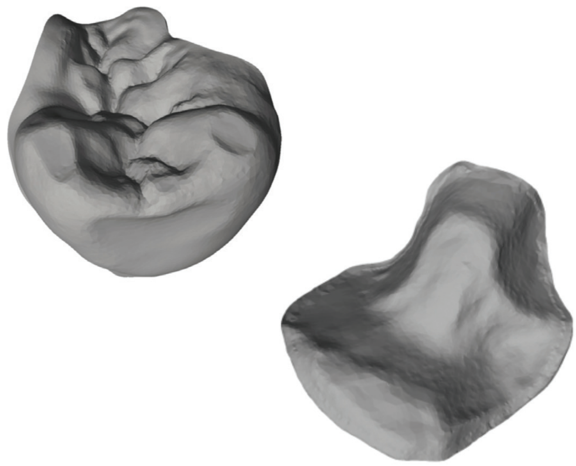
Figure 3 - Photo of crown lengthening procedure to re-establish the biological width

Figure 4 - Peri-apical radiograph of the tooth after root canal re-treatment and crown lengthening

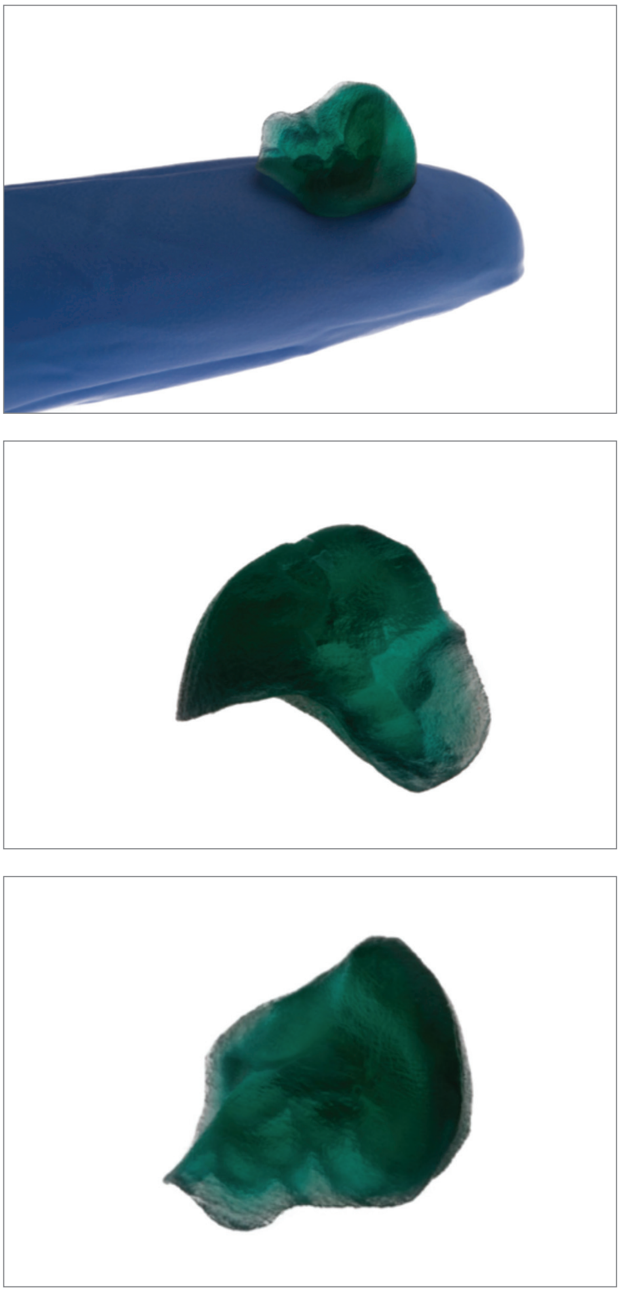
Figure 5 - Occlusal view of the onlay preparation on the mandibular right first molar

After preparation digital impression was made where the tooth preparation, the maxillary and mandibular arch and patient´s occlusion were scanned with an optical intraoral scanner (Trios 3Pod color, 3shape, Copenhagen, Denmark) following the manufacturer's instructions. Then a provisional restoration was fabricated using photo-polymerized provisional material (Fermit N, Ivoclar Vivadent, Schaan, Liechtenstein).

For the laboratory procedures and design of the onlay restoration, specific CAD software (Dental Sytem, 3Shape) was used. STL file of the digital onlay restoration was obtained (Figures 6a-b) and sent to CAD specialized dental technician in a dental laboratory. Thereafter, using the STL file, polymer castable onlay restoration pattern (Visijet M3 DentCast, 3D Systems, Budel, Netherlands) was prepared using a multijet printer (Projet MJP 3600 Dental, 3D systems, Budel, Netherlands) at 15 μm layer thickness (Figure 7). The production of the pattern started with CAM processing and followed by model fabrication and post processing the 3D object, which is specific to the technology and the printer used. The pattern was manufactured by a dental laboratory specialized in additive manufacturing technologies. CAM processing involves adding the supporting structures, specifying the build up variables and parameters for slicing the model on the computer to generate the information that controls the 3D printer. Model fabrication is based on building the object using the sliced file on the 3D printer. Afterwards, the build platform was inserted on the top of a cold blank plate inside of the fridge. Finally, the pattern was separated from the building plate of the 3D printer. Post-processing requires cleaning the object from physical and chemical bath to remove the supportive material and additional polymerization to complete the polymerization process. The printed object was placed in a non-metallic basket filled with >99% isopropyl alcohol in the ultrasonic cleaner at 30ºC. When all the supportive material was completely dissolved, the pattern was removed from the cleaner and subjected to second ultrasonic cleaning in >99% isopropyl alcohol. Finally, the pattern was removed and dried.

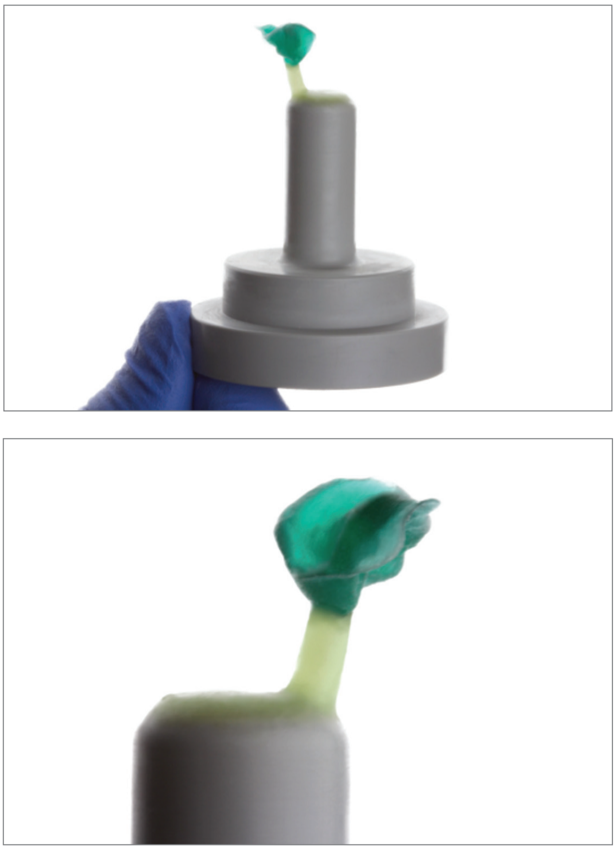


Figures 6 - a) Occlusal view and b) Intaglio surface of the digital design (STL file image) of the onlay restoration



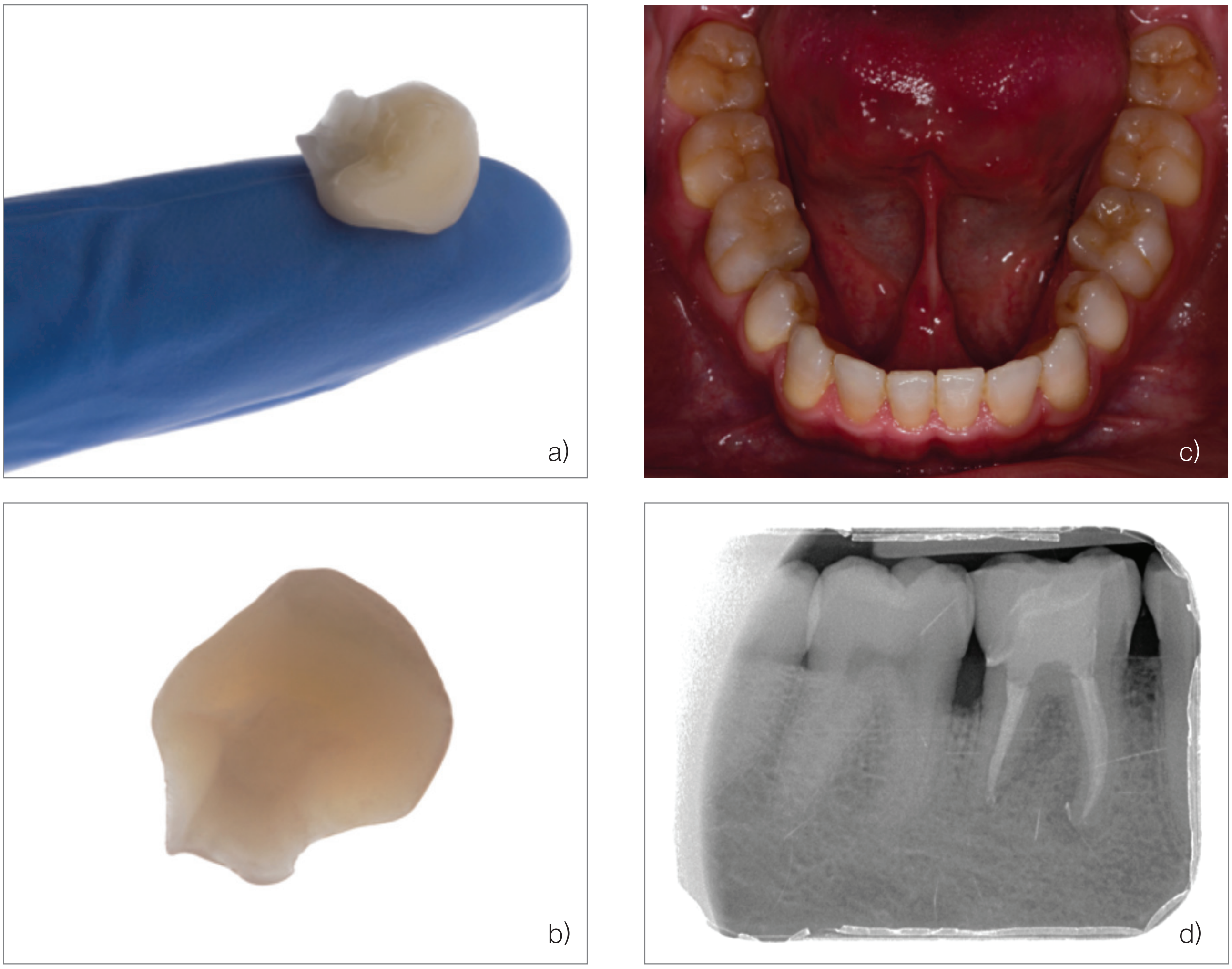
Figures 7 - Photos of a) castable 3D printed pattern of the onlay restoration, b) occlusal and c) intaglio surface

In order to press the 3D printed castable pattern, 10 g lead sprue was attached to the lingual surface of the pattern. According to the instructions of the manufacturer, the recommended length of the wax wire was 3-8 mm and 15-16 mm including the wax-up pattern and the angle between the ring base and the sprue was between 45-60° (Figures 8ab). The pattern was invested (IPS PressVEST, Ivoclar Vivadent) following the manufacturer's recommendations as regards to powder/liquid ratio, vacuum mixture, mixing time and setting time (burn out temperature: 850°C, 1 h). Then lithium disilicate ingot (LT A2 IPS Emax.Press, Ivoclar Vivadent) was pressed following the manufacturer`s indications. After cooling to the room temperature for about 60 minutes, it was divested using a diamond disc to separate the plunger from the investment ring. Rough divesting was achieved using glass beads at 4 bar pressure and fine divesting was performed using reduced pressure of 2 bar preasure. The onlay restoration was placed in 5% hydrofluoric acid (Invex Liquid IPS emax.Press, Ivoclar Vivadent) in a plastic cup for 15 minutes to remove the residues of 100 μm Al2O3 at 1-2 bar pressure. The sprue was removed using a diamond bur and polished under water-cooling (Figures 9a-b).



Figures 8 - Photos of a) sprued of the 3D printed castable pattern, b) intaglio and c) occlusal surface

At the second clinical appointment, the onlay restoration was bonded to the tooth using dual-polymerized resin cement (Rely-X Lava Ultimate, 3M ESPE) following the manufacturer's instructions under rubber dam isolation (Figures 9c-d). After excess removal, the contact point was controlled using dental floss and verified that the contact to the neighbouring tooth was present and floss movement showed no interference. Finally, occlusion was controlled using 40 μm articulator paper (Bausch Arti-Check articulating paper, Dr. Jean Bausch GmbH & Co., Köln, Germany). Premature contact was not noted on disto-lingual cusp and removed using a bur (8368L.314.016 komet Dental). The onlay was then polished using specific lithium disilicate polishing burs (Astropol P, HP Ivoclar Vivadent).



Figures 9 - Photos of a) pressed lithium disilicate only restoration after polishing, b) occlusal and the intaglio surface of the restoration, c) after cementation, d) peri-apical radiograph after delivery of the onlay

DISSCUSION

Due to the advances in intraoral digital devices, dental softwares for the digital design of the restoration and the incorporation of AM technologies, complete digital workflow in dentistry both for clinicians and the dental technicians expanded through which conventional dental laboratory work could be minimized. In this clinical report, the pattern for an onlay restoration was fabricated using AM methods.

One important aspect compared to conventional wax-up procedures is the precision with AM methods. The accuracy and precision of these technologies could be affected by multiple factors such as layer thickness [16], number of layers needed [2], amount of supportive material [2], building direction of the 3D object [17] and the meticulousness of the post processing process. In a previous study, manufacturing tolerance of four polymers used for AM printers, showed accuracy results ranging between -61 and 92 μm [18].

The intraoral digital devices and the AM technologies have to been considered as tools that help the clinicians to develop a treatment in a more efficient way. The intraoral scanner used in this study (TRIOS 3 Pod color, 3shape) allows the clinician to check the inter-occlusal space and the path of insertion of the tooth preparation. These features enable the clinician to perform the changes needed before the impression is sent to the dental laboratory. Such devices also improve the communication between the dental professionals. However, the clinical parameters and principles do not differ from the conventional ones, meaning that the tooth preparation needs to be performed and corrected where needed by the clinician. For the correct reproduction of the intaglio surface of the onlay restoration, the internal angles of the tooth preparation need to be rounded, as the AM technologies cannot reproduce curved surfaces precisely [19].

AM technologies could be considered more economical to fabricate castable patterns as they do not waste material [20-22], and no additional tools are required [22,23]. Furthermore, 3D printing allows for printing more than one pattern at a time. In this clinical report, only one onlay restoration was made which could have been also restored with indirect or direct resin composite where the latter require more skills of the clinician during build up. However, AM technologies may save time for the restoration of occlusal wear cases due to erosion where multiple occlusal onlays need to be made for the complete arch. Furthermore, AM technologies present certain advantages compared to milling procedures since during milling, the tool size and the tip of the milling bur limits the desired fit and final shape of the fabricated object especially at the occlusal and marginal aspects [7,8,23]. Thus, it may be reasonable to argue that AM technologies are capable of reproducing a more detailed occlusal anatomy of a printed pattern for the subsequent pressed lithium disilicate restoration. Yet, post processing adds time to the workflow and in that respect direct resin composites could still be considered more efficient especially for fabrication of single restorations.

SUMMARY

In this clinical report, a technique was described for the fabrication of a 3D printed castable pattern for lithium disilicate onlay restoration. 3D printed patterns could be an alternative to conventional handmade wax-up or milled patterns that also allows manufacturing complex occlusal anatomical surfaces.

DISCLOSURE

The authors claim to have no financial interest, either directly or indirectly, in the products or information presented in the article.

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