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Selective Laser Melting Technique In Fabrication Of Partial Denture Metal Framework.

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ABSTRACT

Selective laser melting technique is form of 3D printing, and has been increasingly used in dentistry. Literature data about clinical procedure and performance of this kind of 3D printing technique are scarce. The purpose of this article was to show clinical case of production of removable partial denture with metal framework made with selective laser melting technique.
Keywords: selective laser melting, 3D printing, partial denture, metal framework.

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INTRODUCTION

3D printing is creation of 3D models from computer-aided design model (CAD). It is independent from technical performance or material that is used. Author of 3D technology is considered to be Charles W. Hull who made the printer prototype in 1984 [1].

Uses of 3D printing in dentistry include the production of drill guides for dental implants, the production of physical models for prosthodontics, orthodontics and surgery, the manufacture of dental, craniomaxillofacial and orthopedic implants, and the fabrication of copings and frameworks for implant and dental restorations [2].

Selective Laser Melting Technique (SLM) is 3D printing technique increasingly been used, especially in prosthetic dentistry [3]. SLM is production procedure where addition of material creates metal components directly from 3D computer-aided design model (CAD). Previously created 3D file of the future metal object (for instance metal framework of the partial denture), and divided on vertical and horizontal layers (using CAD system) is send to the SLM device. High power laser beam of the SLM device fuse layers of metal powder obtaining objects morphology [4]. Laser has sufficient power to melt the powder particles, which fuses them into thin solid layer. After formation of the single layer, the process of melting is continued layer by layer until the completion of the object [4,5]. The metal frameworks are than sand blasted, polished, inspected and ultrasonically cleaned [5].

Partial dentures and overdentures are common form of therapy in the treatment of partial edentulism. Although dental implants are usually first treatment option, due to large bone resorption, patient’s desires and (mostly) financial reasons, partial dentures are still indispensable type of dental treatment [6]. Partial dentures enable prosthetic treatment for missing teeth in all parts of upper and lower dental arches. Studies confirmed patient satisfaction with partial dentures and with overdentures [7,8].

The purpose of this article is to show case report of the use of selective laser melting technique in fabrication of partial denture (metal base) with Cobalt Chromium Molybdenum (CoCrMo) alloy.

CASE REPORT

The patient (58) came to the clinic because of the need for rehabilitation of the partial edentulism in the lower jaw. Dental status in the lower jaw included 48, 42, 41, 31, 32, 33 and 38. Teeth 38 and 48 were mesially inclined. Dental implants were proposed, which patient refused. Due to unfavorable position of the remaining teeth, dental bridge was contraindicated. In agreement with patient, decided therapy was partial denture with metal framework.

First, irreversible hydrocolloid impressions (Aroma Fine Plus, GC, Tokyo, Japan) of the upper and lower jaws were made. Lower and upper casts were poured. Custom tray for the lower jaw functional impression was made out of light cured acrylic resin (Unitray, Polident, Volcja Draga, Slovenia). Mandibular functional impression was taken biphasic. Edges were determined with the use of the resin compound (Iso Functional, GC, Tokyo, Japan), while the impression was made with the silicone material (Xantopren, Heraeus, Hanau, Germany). Working cast was made out of type IV gypsum (Polistone, Polident, Volčja Draga, Slovenia). Working cast was scanned with digital scanner, and on the obtained digital cast (Figure 1) was modeled desired metal framework of the future partial denture. Obtained CAD model was sent to the SLM machine. Figure 2 shows finished metal framework produced with the SLM technique (unpolished). Metal framework was processed (milled, electrolytically polished and mechanically polished using rubbers, brushes and paste for high gloss). After fabrication of metal framework, the partial denture was completed with standard procedure. Metal framework of the partial denture was checked in mouth for fitting (Figure 3). Occlusal rims were made out of pink wax. Bite registration was determined using zinc oxide eugenol paste (Kerr, Luralite, Orange, California, USA). Upper cast was transmitted to articulator using average facebow (SAM 2, SAM Präzisionstechnik GmbH, Munchen, Germany). Lower cast was attached to the articulator with bite registrations. Technician setup the teeth on the lower partial denture. Teeth arrangement was checked in the mouth. Partial denture was polymerized and finished in usual manner. Figure 4 shows finished lower partial denture in patient’s mouth. Occlusion was checked and after small corrections denture was given to the patient. During a clinical evaluation after seven days the patient once again expressed its satisfaction with the lower partial removable denture.

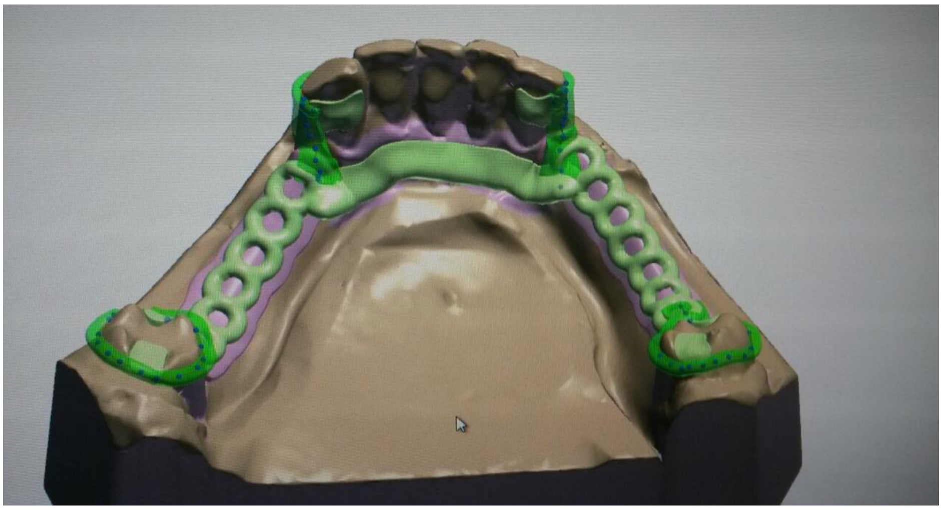

Figure 1. Digital cast with modeled metal framework of the removable partial denture.

Figure2. Finished metal framework produced with the selective laser melting technique (unpolished).

Figure 3. Metal framework of the partial denture checked in the mouth for fitting.

Figure 4. Finished removable partial denture in patient's mouth

DISCUSSION

The conventional method (lost wax technique) of production of partial dentures and overdentures metal framework includes series of steps which increases the possibility of errors, due to procedure technology and human factor. Errors can happen during: impression phase, pouring casts, surveying the master cast, block out and relief of the master cast, duplicating procedure, waxing the framework, spruing, investing and casting. With SLM technique in fabrication of removable dentures metal framework, some of this steps are missing or they are done digitally. Significant reduction of procedure steps with SLM technique reduces the possibility of errors. With reduction of necessary equipment and materials, lowering of the production costs may be affected in long term.

Most used alloys with SLM technique for partial removable dental prosthesis frameworks and crowns and bridges metal basis are CoCrMo. Selective laser melting technique also enabled use of titanium for removable denture frameworks (because of casting difficulties titanium had limited use in dental prostheses) [9]. CoCrMo alloys are commonly used in removable partial dental prosthesis frameworks as they have excellent mechanical properties, corrosion resistance, and biocompatibility [10-12]. Quian et al [13] studied CoCrMo dental alloys prepared by selective laser melting. Although three types of microstructural defects were occasionally observed (small voids <10 µm, fine cracks at grain boundaries <10 µm, and cracks at weld line boundaries >10 µm), the ultimate tensile strength were higher than casted dental alloy. Authors [13] concluded that the SLM CoCrMo alloys can achieve improved mechanical properties than their casted counterparts, implying they are "defect-tolerant". Pompa et al [14] studied conventional methods and laser-assisted rapid prototyping for manufacturing of fixed dental prostheses. The authors concluded that the marginal fit of the fixed dental prostheses is better with rapid prototyping via SLM than conventional manufacturing systems (lost wax technique). With emerging production of the SLM made dental component, biocompatibility of those SLM products were of primary concern. Studies observed biocompatibility of CoCrMo dental alloys fabricated by selective laser melting technique [15,16]. Hedberg et al [15] studied corrosion susceptibility and extent of metal release (measure of biocompatibility) of the SLM fabricated CoCrMo and cast CoCrMo alloys. SLM fabricated alloys had decreased corrosion and metal release susceptibility compared with the cast alloy. It should be noted that the susceptibility for corrosion and metal release increased with an increased number (area) of laser melt pool boundaries [15]. Although many studies investigated use of 3D printing techniques in dentistry [13,15-18], with mostly obtained favorable results [12,13,15-18], clinical studies of performance in mouth after certain period of time are necessary.

CONCLUSIONS

Selective laser melting has potential to replace lost wax technique in fabrication of partial denture metal framework. Reducing the number of stages in fabrication of partial denture metal framework, selective laser melting enabled reduction of the time needed along with financial benefit. Partial denture metal framework mechanical properties and biocompatibility are the same or even better than with lost wax technique.

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