Review Article

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Direct Metal Laser Sintering in the Fabrication of Crowns and Bridges

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ABSTRACT

Background: Dental technology is undergoing advancements at a fast pace and technology is being imported from various other fields. One such imported technology is direct metal laser sintering technology for casting metal crowns. Laser sintering is a relatively new method compared to conventional casting procedure. Direct metal laser-sintering (DMLS) is a well-known method for e-Manufacturing, the fast, flexible and cost-effective production directly from 3D CAD data. The DMLS method is a newly introduced technique for producing metal FDPs. This article will discuss the process of laser sintering for making metal crowns and fixed partial dentures with a understanding of their pros and cons.

Keywords: DMLS-Direct Metal Laser Sintering, CAD-Computer Aided Design.

INTRODUCTION

Dental prostheses have long been conventionally produced primarily from metal through the use of casting techniques. Dental models for appropriate restoration of prostheses and for checking the quality have been produced through time-consuming production and preparation of cast dental impressions. Currently, though, dental technology is undergoing a radical shift and a process of industrialization that has already taken place in other markets. The use of digital dental technology is on the rise and manufacturing processes are being automated. CAM milling technology is often referred to as subtractive process, as milling involves taking a block of material and cutting away everything that is not necessary until the final restoration emerges. In contrast, additive processes involve adding material layer by layer to build the final product.

Rapid Manufacturing

The term 'Rapid Manufacturing'(RM) has been coined to describe the manufacture of end-use parts and components by additive layer technologies such as Selective Laser Sintering (SLS), Stereolithography (SLA) and the most recent process, Direct Metal Laser Sintering (DMLS). Basically four different 3D printing technologies (additive process) are being used in dental industry: stereo lithography apparatus, digital light projection, jet and **direct metal laser sintering (DLMS or DMLS or just MLS).** Each system varies in the materials available, how these materials are solidified and how they can be used.

Laser-Sintering was first introduced by Deckard and Beaman. Laser sintering is basically manufacturing of solid parts by solidifying powder like materials layer-by-layer by exposing the surface of a powder bed with a laser or other energy beam.

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BASIC PRINICPLE

Laser sintering is the newest technology in metal manufacturing. DMLS is a manufacturing process for producing complex 3D components directly from 3D CAD data without using any machining. DLMS requires three inputs: material, energy and CAD model.

Laser sintering is also referred to as "3D printing" because it builds up framework in a series of successively thin layers (0.02–0.06 mm) . A high powered laser beam is focused onto a bed of powdered metal and these areas fuse into a thin solid layer. Another layer of powder is then laid down and the next slice of the framework is produced and fused with the first. When all the layers have been built up, the solid copings and bridge frameworks are taken from the machine, sand blasted polished, inspected and ultrasonically cleaned. The unused powder that remains is filtered and used in the next batch.

The basic principle of the DirectMetal Laser Sintering (DMLS) Technology is to melt down thin layers (20 ÷ 60 μm) of Metal Powder with an electronically driven LASER beam (200W)• Layer by layer, it is possible to build any kind of shape and geometry, even those which are impossible to obtain with anyother kind of technology. The accuracy is ± 0,05mm.

MATERIALS

The material used is powder-based working material. MLS crowns have a primary composition of chrome cobalt alloy. Molybdenum,tungsten, silicon, cerium, iron, manganese and carbon are the other ingredients used. They are nickel and beryllium free. The material is a mix of particles of the size of 3–14 lm. Energy used is a high powered laser beam (200 WYtterbium fiber optic laser). This energy is used to melt the alloy powder.

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The material used is specially developed powder blend containing a range of alloying elements with the particle size of 3-14 µm. A special version of CoCr superalloy developed by EOS CobaltChrome SP1 and later modified to SP2 is available which is used exclusively for metal-ceramic restorations energy source is a laser beam (Yb-fibre or CO2) of 200W power which fuses thepowder layers of metal of 20µm thickness. The data from the CAD model guides layering process to fabricate the shape of the restorations. These layers correspond to the virtual cross-sections from the CAD model.The standard data interface between CAD software and the machine is the STL (Standard Tessellation Language) file format. The STL file creation process mainly converts the continuous geometry in the CAD file into a header, small triangles, or coordinates triplet list of x, y, and z coordinates and the normal vector to the triangles. The smaller the triangles the closer they are to reality.

TECHNIQUE FOR DENTAL RESTORATIONS

CAD process of producing copings by DMLS technique is carried by scanning the impression or the poured cast using the optical scanner. The crown/bridge is designed over this digitilised cast using CAD software. In the dental office, an impression of a tooth preparation is made to start with, after routine diagnosis and treatment planning. The impression could be a conventional or a digital impression. In the intermediate dental laboratory, the impression is poured with type IV dental stone and a model is prepared. The model is scanned, or the impression itself is scanned using extra oral scanners or the third option is the tooth preparation is scanned in the patients mouth using intra oral scanners and the crown/bridge is designed using CAD design and sent to the central processing unit. The central processing unit is usually a remotely located laboratory with the laser sintering equipment. Special CAM software is used to import a CAD file, usually supplied in the STL format from a scanner/CAD software. CAM software further slices the parts into discrete horizontal layers.

This data is then sent to production centre which are usually the remote laboratories equipped with DMLS machines. The machine converts the CAD software into STL file which helps in carrying out laser sintering of Co-Cr powder, layer by layer of thickness 20 μm in an inert atmosphere. After a layer is built, the building platform is lowered and a new layer of powder is applied. The procedure is carried out until the desired shape of the coping is obtained.Upto 90-120 units of crown/bridge can be obtained per run of the machine. A total of 450 units in 24 hours fully automated and of high accuracy. The DMLS process is performed by two different methods, powder deposition and powder bed method they differ in the way each layer of powder is applied. The powder bed method is more popular presently, as they offer faster speeds. Inside the build chamber area, there are two platforms, material dispensing platform and build platform. The material dispensing platform along with a re-coater blade is used to move new powder over the build platform. The metal powder is fused into a solid part by melting it using the focused laser beam. Parts are built up additively layer by layer, usually 20 μm thick. After a layer is built the build piston lowers the build platform and the next layer of powder is applied. This process allows for highly complex geometries to be created directly from the 3D CAD data, fully automatically without any tools, producing parts with higher accuracy and detailed resolution, good surface quality and excellent mechanical properties. Finally the support material is cut off from the copings/crowns/bridges.

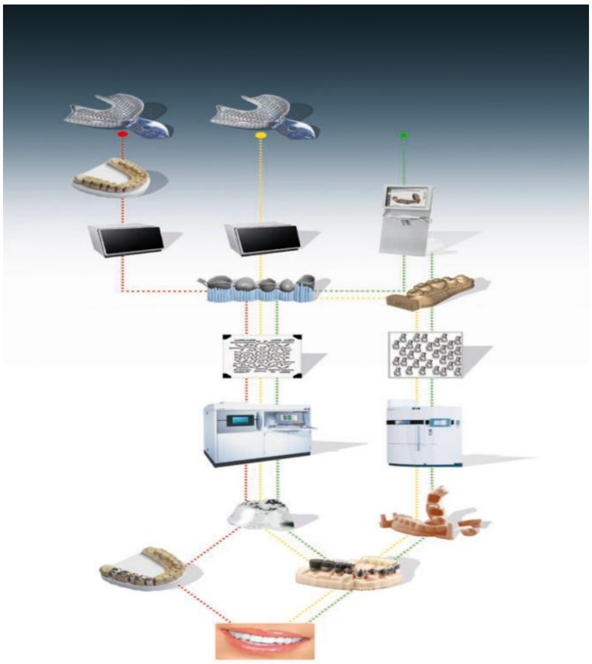

Fig 1: Diagram showing full process of fabrication.

ADVANTAGES

MLS crowns and bridges are made of a particle size of 3–14 μm. This combined with very fine point laser (0.1 mm) results in a density of 99.9 %, resulting in stronger copings. The densely sintered crowns have practically no voids. The process results in highly accurate, well detailed restorations. Marginal discrepancy is low and within clinically acceptable range with the restoration possessing consistent quality and strength . DLMS is a clean alternative to casting. Messy tasks of disinvest, cleaning molds, elaborate steps can be dispensed with. The use of automated scanning and CAD software results in full control over the framework design. Coping thickness, pontic design and cement thickness can all be standardized with this method. Laser sintering is a computer-controlled, precise process that ensures consistent work quality. The possibilities of inclusions or defects that are commonly introduced in the manual casting methods are dispensed with. Multiple unit framework usually suffers from distortion in the conventional technique, DMLS is more predictable with improved marginal fit

With a build envelope of 250 × 250 × 185 mm and the ability to grow multiple parts at one time, though the initial investment is high, they are very cost and time effective. A dental technician can produce at best about 20 units per day using conventional casting procedures used today whereas; use of fully automated laser sintering technology can produce about 450 units of high quality crowns and bridges in 24 h with an efficiency of 90 units per run of the machine [4]. For the dentist, chair side time is reduced and time required in the dental laboratory is enormously less.

CONCLUSION

Laser sintering is relatively new; manufacturers claim that the technique is easy to use, produces accurate restorations, simplified post processing procedures, free of porosity unlike conventional castings and improved electromechanical characteristics. But, further long term studies on the fit and properties of laser sintered crowns and fixed dental prostheses, if encouraging, could result in their widespread clinical use. The rapid advancements in the digitalized processes will continue, making this computerized technique more cost effective. More research will enable this technique to become more competitive. Laser sintering is a relatively new method compared to conventional casting procedure. The accuracy of CAD/CAM prosthetic frameworks may rely on the precision of the scanner that reads the abutments, on the ways in which the software can transform the scanning data into a 3D model on the computer,and on the accuracy of the machine that uses CAM to produce objects from the CAD data. Therefore, CAD/CAM techniques could minimize some of the risk factors related to casting procedures, as proven in the DLMS group, where few critical manual steps are present. The proper use of the DMLS technology may result in the most predictable fabrication method under the tested experimental conditions.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

REFRENCES

1. Monica S, Nikita S, Bhavna S, Arvind S, Sonali R. Direct Metal Laser Sintering – A Digital Alternative To Conventional Casting. Journal of Health Hazard July 2014;3:1
2. Vijay VK and Vidyashree NV. Direct Metal Laser Sintering: A Digitised Metal Casting Technology J Indian Prosthodont Soc (Oct-Dec 2013) 13(4):389–92
3. Ian Halliday. Making the impossible-possible with DMLS. 3TRPD.DMLS
4. Ing. R F The DMLS Technology iTechMetal e-manufacturing technology for a new concept in Design
5. EOS e manufacturing solutions brochure
6. Shellabear, O. Nyrhilä. DMLS – DEVELOPMENT HISTORY ANDSTATE OF THE ART M. LANE 2004 conference, Erlangen, Germany, Sept. 21-24, 2004
7. Gareth T, Renishaw. Introducing CAD/CAM for mainstream dentistry: Laser PFM. Renishaw 2010.
8. Traini T, Mangano C, Sammons RL, Mangano F, Piattelli A (2008) Direct laser metal sintering as a new approach to fabrication of an isoelastic functionally graded material for manufacture of porous titanium dental implants. Dent Mater 24:1525–33
9. Ortorp A, Jonson D, Mouhsen A, Vult von Steyern P (2011) The fit of cobalt-chromium three unit fixed dental prostheses fabricated with 4 different techniques: a comparative in vitro study.Dent Mater 27:356–63
10. Ucar Y, Akova T, Akyil MS, Brantley WA (2009) Internal fit evaluation of crowns prepared using a new dental crown fabrication technique: laser sintered CO–Cr crowns. J Prosthet Dent 102:253–59.
11. Bindl A, Morman WH (2005) Marginal and internal fit of all ceramic CAD/CAM crown copings on chamfer preparations. J Oral Rehabil 32:441–47.
12. Kokubo Y, Ohkubo C, Tsumita M, Miyashita A, Von Steyern PV,Fukushima S. Clinical marginal and internal gaps of Procera all ceramic crowns. J Oral Rehabil. 2005;32:526–30.