Additive Manufacturing for Medical Technology

Dental Industry

Bralco Advanced Materials Pte. Ltd. Singapore
The emerging trend of digital dentistry due to its precision, accuracy, and efficiency has played an instrumental role in shaping the future of the global dental 3D printing market. The growing adoption of technology for making implants, crowns, bridges, dentures, and surgical guides due to aging population will increase the popularity of dental 3D printing in the coming years.
1. Introduction to Additive Manufacturing for Dental Industry
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Problems with Traditional Manufacturing Methods

**Price** - A single tooth implant can cost up to $5,000 and is hardly covered by insurance.

**Lack of “make to order” implants** - Standard implants of various sizes had led to discomfort and worsening pain when aligned with the patient’s dental structure.

**Increasing demand for complexity and tight tolerance** - Difficult to machine titanium of complex features with accuracy.
A **LEAN-ER** manufacturing approach.

Enhanced quality and consistency.

3D printers are well-positioned to provide dental solutions to their patients within shorter time frames.

Digital files and hard models printed on-demand may accelerate dental professionals meet compliance requirements.
Results of AM Implementation

Financial Freedom - Affordable and accessible platform for individuals with financial constraints.

Patient Satisfaction - The opportunity to improve the dental experience for the clinician and patient.

Digital Manufacturing - It is possible to take a contactless 3D scan of a patient's mouth as a prelude to crown, bridge and denture fabrication.

Tackling Reconstructive Surgery - Mandibular reconstruction and lower arch implant rehabilitation.
Dental by Applications - Materials Development

Dental implants using additive manufacturing have long gained acceptance by the medical community and are now being used widely to fabricate accurate braces and dental restorations. This has, in turn, led to a number of companies developing 3D scanning software, materials for crowns and mandible sets, and dental restoration pieces.
Product: Crowns and Bridges

Material: Biocompatible Cobalt Chromium Molybdenum Alloy

AM Process: Selective Laser Melting (SLM)

The CE-certified material EOS Cobalt Chrome SP2 (CE 0537) and the EOSINT M 270 system are used for the digital production of crowns and bridges.
Product: Removable Partial Dentures (RPD) Frameworks

Materials: Cobalt Chrome Alloy and 316L Stainless Steel

AM Process: Selective Laser Melting (SLM)

Advantages of AM RPD Framework:

- Reduced maintenance costs.
- Eliminate materials waste (alloy, wax and investment material).
- Improved health and safety features.
- Flexibility to alter design and remanufacture digitally.
- Shorter process workflow.
Product: Novel Custom Abutments

Materials: Cobalt Chrome Alloy and Titanium Alloy

AM Process: Selective Laser Melting (SLM)

Advantages and Benefits:

➢ Create screw-retained crowns.
➢ Use of standard porcelains.
➢ A pre-polished emergence profile.
➢ Suitable for a range of implants.
A 37-year-old male presents with a history of trauma to the anterior mandible. At the time of the incident, teeth Nos. 26 and 27 were extracted without ridge preservation. The patient was left with large crestal and buccal defects postextraction (figures 1 and 2).

Options for ridge augmentation and delayed placement were discussed. The patient chose to have implants placed due to the existing condition of the bone, with the understanding that pink prosthetics would be necessary.

A CBCT scan was taken and imported into the implant planning software. A digital diagnostic wax-up was done by inserting teeth Nos. 26 and 27 into ideal position. With an extremely thin ridge and lack of crestal height, it was determined that space was available for a single Implant. Placement was planned for a screw-retained prosthesis with an anterior cantilever (figures 3 and 4).
A tooth-supported fully limiting surgical guide was designed in the planning software and sent to the 3-D printer for fabrication. Once the guide was fabricated, a guide tube matching the final implant drill diameter was inserted into the guide (figure 5).

A full-thickness flap is reflected to visualize the bone and confirm positioning through the surgical guide. The guide is designed with windows to visualize proper seating. The surgical guide fully limits the implant drill in all dimensions, including depth, making it possible to drill to the final osteotomy depth and width with one drill. The implant fixture was placed and allowed to heal for four months with a healing abutment. The presurgically planned prosthesis was lab fabricated and delivered (figures 6 and 7).
The patient was pleased with the final result. A CBCT scan allowed this difficult surgical and esthetic case to be planned thoroughly beforehand. 3-D printing economically realized the planning in the actual surgery and prosthesis. 3-D printing in surgical guide fabrication allowed for more efficient and precise implant placement and restoration (figures 8 and 9).
Case Study 2

48 year-old radio producer, Susie Robinson has had 15 operations over the years to repair her damaged jaw following the crash in 1989. Yet none of the procedures had managed to provide a lasting solution. For the last 15 years, Susie has relied upon dental implants to hold her false teeth in place. However, when these cracked her dentist realized her jaw had deteriorated further and suggested she found a more unorthodox alternative.

Using the 3D printed titanium approach, Robinson did not have to undertake several procedures and her surgery lasted only an hour. Susie Robinson has now made a full recovery and it seems her jaw can finally recover with the titanium implant. Following the implantation procedure, Robinson’s jaw will now grow bone around the titanium, using the implant as a strong base structure.

Robinson was sent to see Dr George Dimitroulis who introduced her to a new procedure that would not involve grafting bone from her hip and undergoing several operations. Dimitroulis’ procedure would require only one surgery to implant the device, once she had been scanned and the jaw 3D printed.

The implants in Susie’s jaw before the surgery. Image via The Sydney Morning Herald.
Case Study 3

Patient Specific Implant (PSI): Reconstruction of Mandible bone

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An innovative and complicated surgical procedure was successfully performed at Rambam Medical Center in Haifa, Israel, on June 26, 2018. The procedure was performed at the Department of Oral and Maxillofacial Surgery by Prof. Adi Rachmiel, Dr. Omri Emodi, Dr. Nseir Saleh and Dr. Efi Weitman, using titanium 3D printed implant, manufactured by STI Laser Industries.
Case: 45 years old male, suffering from ameloblastoma, an aggressive tumor that severely damaged the patient's mandible bone.

Surgical procedure: The surgeons resected the tumor and performed the mandible reconstruction using a titanium implant that was tailored to patient's anatomy.
The surgery planning and implant design were performed by Dr. Jean Ramon and his team from the Israeli Institute of Metals - Technion. The implant was manufactured by STI, using EBM 3D printing technology and post-processing state-of-the-art finishing techniques.
Electron Beam Melting (EBM) provides enhanced implant quality by creating an optimal surface roughness to facilitate osteointegration.
According to the doctors, the patient is well and recovering.
STI Laser Industries is the only company in Israel that is certified by an international notifying body - DEKRA - to offer PSI using its advanced EBM technology and proprietary post-processing surface finishing techniques to improve fatigue-resistance and biocompatibility.
Patient 'V', age 40, presented with an upper arch containing one remaining tooth, at position 14, a right upper pre-molar. When discussing the possible options with the patient we looked at the using of a denture. This was quickly set aside as the patient had issues with this type of prosthetic due to the following reasons: the patient has a severe gag reflex, the age of the patient meant long term there would be severe shrinkage of the bone adjacent to the denture, and dentures even when well placed can be uncomfortable. Finally the patient associated dentures with people much older than himself so I have to take into account the patients mental wellbeing.

Patient "V" returned for a second consult after I suggested that the way to proceed would be for him to have five dental implants placed to be followed by a fixed prosthetic bridge. The patient agreed with this after considering the costs involved for him and the time required placing the implants with the prescribed six month waiting period before I can fix the prosthetic bridge.

Then using an ‘O’ shaped scalpel and proceeding through the holes milled in the DIG I removed a circular piece of the gum through to the level of bone creating a clear and unobstructed access entry point for the dental implant to enter.

Once this was done I placed the correct sized sleeves into the holes milled into the DIG and began placing the dental implants through the sleeves which have holes for the dental implant to slide through. When placing dental implants in the traditional ‘semi-blind’ method you have to gauge depths and angulations by your own eye. When using the DIG this part of the dental implant procedure is removed from the dentist’s purview as all the hard work had already been done in the pre-planning phase of the dental implant procedure. I found when using the DIG I was more confident when placing this many dental implants but I also discovered that the use of the DIG increased the rapidity of the dental implant procedure which is great for the patient.
When reviewing how the dental implant procedure went with Patient ‘V’ I came to the conclusion when placing multiple implants that will require them to rely on each other, as in this case they will anchor the prosthetic bridge, the use of Sheutz Dental Impla 3D Software is an essential tool for any modern clinician to be knowledgeable of. With the use of Sheutz Dental Impla 3D Software I was able to plan the placement of the dental implants with a higher degree of accuracy, have a DIG created which enable me to deliver the dental implants into the patient far more accurately and finally it has proven to be a reduced stress procedure for both myself and the patient.

I could see that the dental implants were placed with more accuracy than if they were placed in the traditional method. The time involved in the actual placing of the dental implants was shortened considerably which is great for the patient as it far less traumatic for them and their gums. I came away from the dental implant procedure feeling highly confident in the quality, accuracy and the safety of the dental implants.

When patients present with requirements for single dental implants* I think the use of a CT Scan for the clinician to use as a guide is suitable. When a patient presents requiring three or more dental implants that will rely on each other I feel the that Sheutz Dental Impla 3D Software will definitely enhance the placing of the dental implants from both the clinicians view and the patients’.
Case Study 4 Cont.
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Questions?

Thank You

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