3D Printing in Implant Dentistry

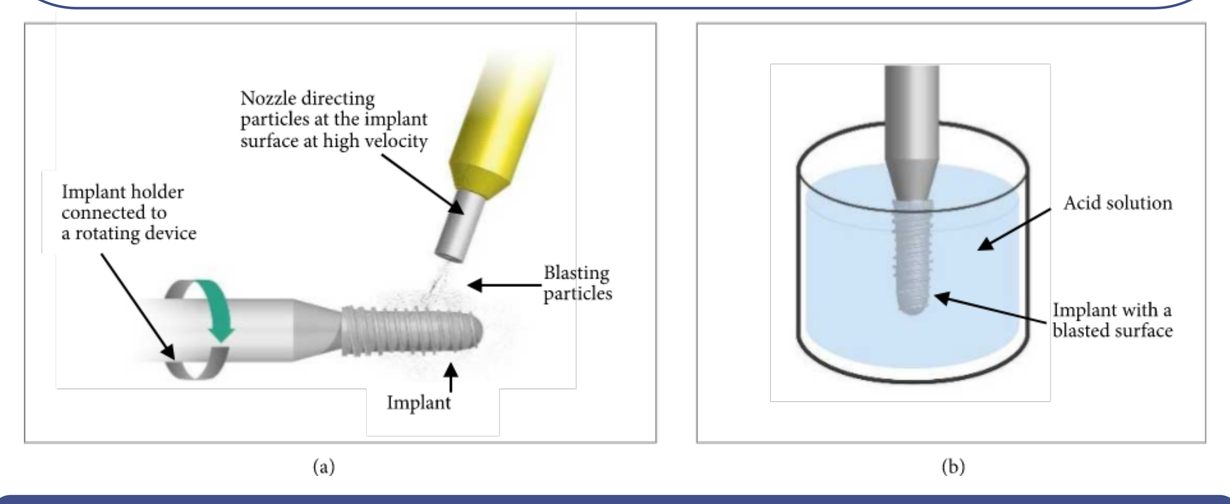
Dorothy Li, DDS
NewYork-Presbyterian Brooklyn Methodist Hospital

INTRODUCTION

Since their introduction into clinical dentistry, dental implants have undergone significant evolution in design, shape and composition. The most widely used implants today are endosseous titanium threaded implants that undergo surface treatments to improve osseointegration and consequent implant survival and success. In recent decades, 3D printing technology has increasingly been implemented in dentistry. While 3D printing of dental implants is a relatively new and understudied clinical concept, preliminary studies have shown that this method of implant fabrication allows for improved implant design and considerable implant success and stability.

CONVENTIONAL IMPLANT FABRICATION

- Dental implants are typically produced from rods of commercially pure titanium (cpTi) or its alloy Ti-6Al-4V (90% Ti, 6% Al, 4% V)
- Building upon research by Dr. André Schroeder and Dr. Reinhard Straumann since the mid 1980's the customary implant design used by most dental clinicians has been the endosseous root-form implant
- Implants undergo post processing with application of surface treatments aimed at enhancing osseointegration and healing
  - Sandblasting, grit-blasting, acid-etching, anodization
  - Deposition of hydroxyapatite, calcium phosphate crystals
  - Titanium plasma spraying
  - Most recently, fluoride, antibiotics, growth factors



3D PRINTED IMPLANT FABRICATION

- In the preliminary studies of 3D printed implants, the following methodology for implant fabrication was used: implants were designed and fabricated by a laser-sintered additive manufacturing technique. Using a focused laser beam (CO2 or fiber), powders of titanium alloy are melted and fused into solid parts that compose layers. Layers are built on top of one another to form the implant
- There are several advantages of 3DP implants suggested by preliminary clinical studies
  - Ability to fabricate implants with open-pore structure and controlled porosity at the implant surface, which facilitates formation of new tissue within porous scaffolds and improved healing
  - Easy sharing and handling of patient imaging data
  - Ability to custom design implants for individual patient's anatomy
  - Unlike cutting or milling, can be conducted without molds
  - No post processing steps required

MATERIALS AND METHODS

- Prospective 3-year follow-up clinical study evaluating the survival and success rates of 110 3DP titanium dental implants restored with single implant-supported restorations in 82 patients
- 82 total patients included 44 males and 38 females; age range 26–67
- 110 3DP titanium dental implants were placed with 65 in maxilla and 45 in mandible; 75 implants were placed in healed alveolar ridges and 35 in post-extraction sockets
- Inclusion criteria were good oral health and sufficient bone availability to receive an implant of at least 3.3 mm in diameter and 8.0 mm in length
- Exclusion criteria were poor oral hygiene, untreated periodontal disease, smoking and bruxism
- Implants were placed from January 2010 to January 2012 in four different private dental practices
- 3DP implants were fabricated with additive manufacturing technology and EOS M270 3D printer with Yb (ytterbium) fiber laser system
- Preoperative evaluations included panoramic and periapical radiographs. In some cases, cone-beam computed tomography (CBCT) was utilized. Diagnostic wax-ups were created for all restorations
- Implants were placed with a two-stage technique with a minimum healing period of 2-3 months in the mandible, 3-4 months in the maxilla
- Provisional acrylic resin crowns were placed for 3 months
- Final metal-ceramic crowns were delivered and cemented with zinc phosphate cement or zinc-eugenol oxide cement

RESULTS

- All patients were enrolled in a follow-up recall protocol with professional oral hygiene and clinical and radiographic evaluation of implants and restorations every 6 months
- After 3 years of loading, each implant was evaluated clinically, prosthetically and radiographically
- An implant was categorized as survival if it was in function after 3 years
- An implant was categorized as successful if there was an absence of pain, sensitivity, suppuration, exudation, clinically detectable implant mobility, continuous peri-implant radiolucency, prosthetic complications and radiographic distance between the implant shoulder and the first visible bone-implant contact < 1.5 mm after the first year of functional loading
- Six out of 110 implants failed → implant survival rate of 94.5%
- Of the 104 surviving implant-supported restorations, 6 showed complications and were therefore considered unsuccessful → implant-crown success of 94.3%

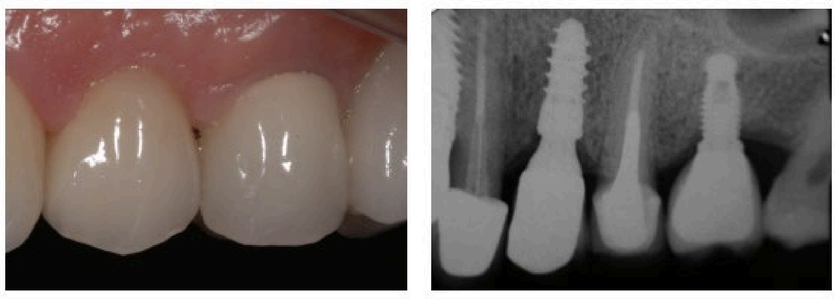


FIGURE 5: A single 3DP/AM titanium dental implant in a postextraction socket of the posterior maxilla: 3-year follow-up control. (a) Clinical picture after 3 years of functional loading. (b) Periapical rx after 3 years of functional loading.

REFERENCES

Abraham, C. M. (2014). A brief historical perspective on dental Implants, their surface coatings and treatments. *The Open Dentistry Journal*, *8*(1), 50–55.

Li, L., Lee, J., Amara, H. B., Lee, J.-B., Lee, K.-S., Shin, S.-W., Lee, Y.-M., Kim, B., Kim, P., & Koo, K.-T. (2020). Comparison of 3D-Printed dental implants with Threaded implants For osseointegration: An Experimental pilot study. *Materials*, *13*(21), 4815.

Tunchel, S., Blay, A., Kolerman, R., Mijiritsky, E., & Shibli, J. A. (2016). 3D printing/additive Manufacturing Single Titanium Dental IMPLANTS: A PROSPECTIVE Multicenter study with 3 years of follow-up. *International Journal of Dentistry*, *2016*, 1–9.

CONCLUSION

Dental implants produced by 3D printing/additive manufacturing technology provide a successful clinical option for the rehabilitation of single-tooth edentulous maxillary and mandibular sites. Weaknesses of this study include the short 3 year period of follow-up and the limited number of patients treated and restorations evaluated.

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