

Additive manufacturing; stereolithography in dentistry



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Introduction:

Digital revolution because of computers has made the previously manual tasks much easier, faster and more reliable at a reduced cost. Such modifications are always welcomed in dentistry, especially from materials and manufacturing perspective. The digital revolution in the form of dental CAD-CAM took place many years ago, since then many modified systems have appeared on the market with great rapidity.

It is expected that another digital dental revolution will take over dentistry in the form of layered fabrication techniques, once they are able to produce high quality dental prostheses. This situation has also posed great challenge for the material scientists in the form of materials that are suitable for long term use in dentistry and oral environment. This can potentially take dental materials research in a totally different direction.

Additive manufacturing:

Dentistry is the most suited field for additive manufacturing, as it is associated with rapid production of customized units made to fit the patient with high degree of precision and accuracy. *In principle* it creates a series of cross-sectional slices from a 3D computer file which are then printed one on top of the other to create the 3D object without any material being wasted. *Additive manufacturing technologies* includes many and Stereolithography (SLA) is one of them.

Stereolithography (SLA)

Stereolithography (SLA) is the most widely used rapid prototyping technology. The term “Stereolithography” was first introduced in 1986 by Charles W. Hull, who defined it as a method for making solid objects by successively printing thin layers of an ultraviolet curable material, one on top of the other.

Materials and Required time:

A number of materials that the industry uses have increased greatly and modern machines can utilize a broad array of photo curable polymers. Timing depends on the size and number of objects being created, the laser might take a minute or two for each layer (a typical run 6 to 12 h). One can now even print 50 to 80 dental crown units in 56 minutes with high quality mode.

Applications in dentistry:

Dental applications are very suitable for processing by means of SLA due to their complex geometries, low volume and strong individualization. Most common are models fabricated from intraoral or impression scans. However, popularity is gaining for orthodontics and removable prosthodontics.

1. Production of anatomical models: SLA models are preferred because of higher strength, higher temperature resistance, lower moisture absorption, and lower shrinkage. They can be sterilized for surgical use, and literature has shown superior accuracy (Barker *et al.*, 1994, Choi *et al.*, 2002, Cunningham *et al.*, 2005). Table-1 summarizes basic characteristics of the three most common types of 3-D models used in the United States. SLA

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clinical models are used as an aid to diagnosis, preoperative planning and implant design and manufacturing. Surgeons use models to help plan surgeries but prosthetists and technologists also use models as an aid to the design and manufacturing of custom-fitting implants. These models are particularly very useful for restorative rehabilitation of oral cancer patients. Medical models are frequently used to help in the construction of Cranioplasty plates. The models are effective tools to facilitate patient education and as a teaching aid for students and junior colleagues.

2. Manufacture of crowns and bridges, resin models: Its use is gradually being extended to include the manufacture of temporary crowns and bridges and resin working models for loss wax casting.

3. Production of removable partial denture frameworks: The removable partial denture frameworks is made using rapid prototyping, SLA technique. It was developed by 3D Systems of Valencia, CA, USA in 1986.

4. Production of individually-customized digital aligner models for orthodontic use: Whole trays of individually-customized aligner models which serve as extremely accurate base-mold tools upon which the clear aligners are then thermoformed, can be produced by this additive technique.

5. Manufacturing of scaffolds for bioengineering and nerve guide conduits: Scaffolds for bioengineering and nerve guide conduits for peripheral nerve regeneration are the newer applications of a similar process i. e. microstereolithography (μ SLA).

Future advancements:

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With the improvements in the speed, reliability, and accuracy of the hardware, additive manufacturing will seriously compete with traditional manufacturing in creating end-use products. Many possible biomedical engineering applications might be available in the coming years.

Conclusion:

It will still be many years before the machines will be able to produce work of a quality that can be achieved by the best dental technologists in the world. For the dental materials scientist these technologies will throw up a whole new way of materials processing and with it the opportunity to use a whole new range of materials.

	SLA models	SLA models	3 D printed models
Material	Acrylic	Epoxy	Starch
Physical properties	Translucent, strong	Translucent, strong	Opaque, brittle
Sterilization	Possible	Not recommended	Not possible

Table-1 Basic characteristics of 3 D models (Choi *et al.* , 2002)

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