



# Stereolithography Models

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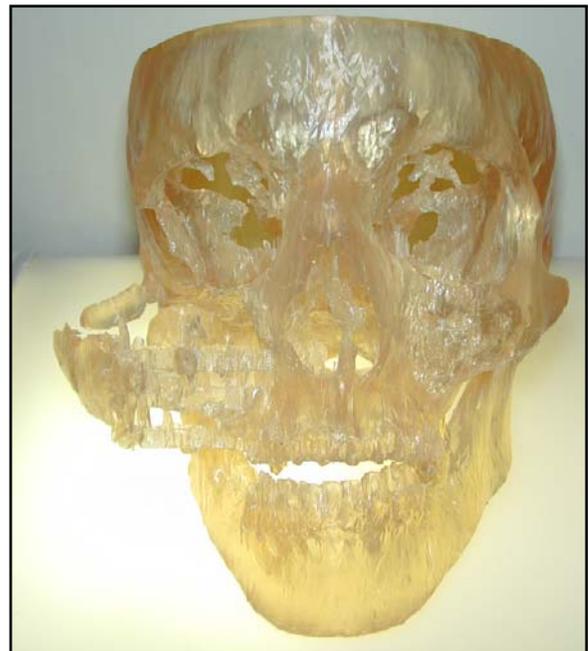
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## Stereolithography

The Stereolithography Laboratory at the MacKown Clinic became operational by May 1997. The process was patented in 1986 by Charles Hull to manufacture models from a computer-aided design database. Stereolithography (SL) was originally used in the automotive industry, and is a rapid prototyping process that creates anatomically accurate, 3-dimensional (3d) epoxy and acrylic resin models. Data files from computed tomography (CT), magnetic resonance imaging (MRI), or laser surface scanning can all be used to create these models.

Advantages of using the 3d models include direct visualization of anatomic structures such as mandibles, maxillae and orbital structures, bone configurations (height and width), sinus cavities, nerve canals, and recently a rib cage with overlying soft tissue. These models can be used as education tools for treatment planning or surgical guides, surgical templates, and even surgical practice models.

Surgeons can rehearse proposed surgeries on critical structures prior to going to the operating room (OR). Using stereolithography models for designing incisions, surgical resections, and measurement of bony grafts facilitates treatment of craniofacial anomalies, dysplasias, and developmental defects. Stereolithography techniques result in immediate savings by reducing OR time. Other benefits to the patient include minimizing wound exposure and anesthesia time,



*AK-47 gunshot injury*

and decreased blood loss. Operating room procedural time can also be reduced by having the surgeon shape prefabricated reconstruction plates prior to surgery. Additionally, custom titanium devices (i.e., distraction osteogenesis devices, fixation devices, custom implants) can be fabricated on the SL models by the dental laboratory located in the MacKown Dental Clinic, Wilford Hall Medical Center (WHMC). These custom devices allow for the treatment of difficult reconstruction cases.

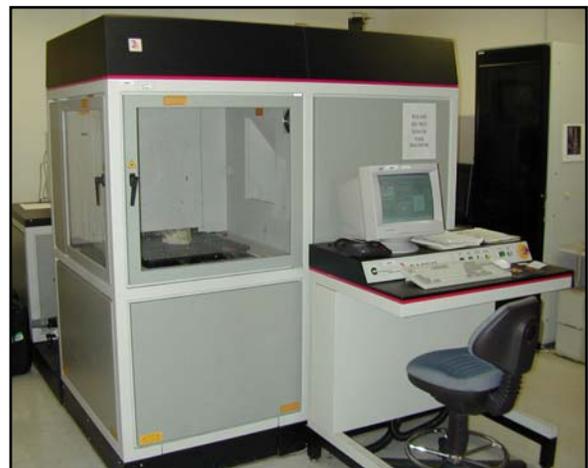
The stereolithography models are semitransparent. The ability to visualize internal anatomic structures (marrow spaces, craniofacial sinuses, blood vessels, etc.) is a tremendous surgical adjunct. The MacKown Dental Laboratory has the ability to provide two-color models. The two-colored models can show the difference in radio-density of various body tissues, such as between brain tissue and calvarium, between nerves and surrounding bone, cartilaginous disks and vertebrae, and between tumors and surrounding unaffected tissues.



*Semitransparent model showing external and internal ear structures*

The stereolithography models are fabricated with a photo-reactive epoxy resins. The properties of epoxy stereolithography models and their accuracy allow for the fabrication of prosthetic patterns which in turn can be converted into casting patterns, then cast into prostheses.

Stereolithography models aid in dental implant design and placement by allowing the prosthodontist or comprehensive dentist to place implant templates in the model. The technology allows for the creation of an SL model with or without the implant template. These procedures allow for better communication with the surgeon for a more predictable treatment outcome. Potentially, with the proper software, this technology will allow for the creation of the implant surgical guide directly on the computer screen and outputted to the SL machine for fabrication.



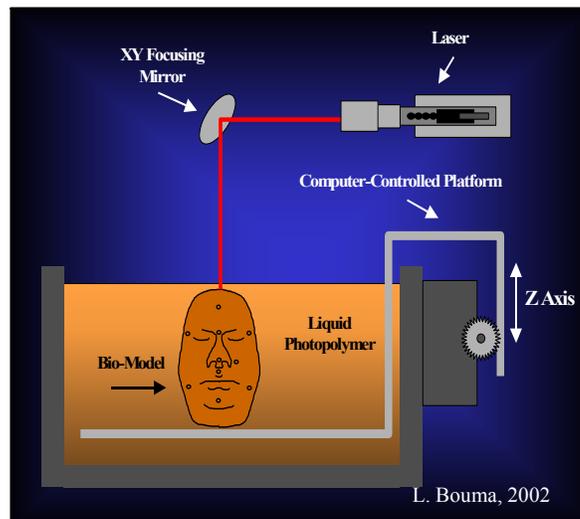
*SLA-500 Stereolithography Machine*

## How it works

The stereolithography apparatus (SLA) at MacKown Dental Laboratory is the SLA-500, manufactured by 3d Systems, Inc., in Valencia, California. The stereolithography-controlling computer directs the sequential curing of a liquid epoxy resin photopolymer (accuGen 100 SL Material) by a Helium-Cadmium or Argon laser via a complex optics and mirror system. The process begins with a vat full of liquid photopolymer and a computer-controlled platform. The platform is lowered into the liquid and raised to just below the surface. The laser draws the individual slices of computerized tomography data layer-by-layer, beginning with the most inferior point of the model. Once this epoxy resin layer becomes laser hardened, the platform supporting the model drops down 0.006" into the vat of photopolymer and the laser traces the next cross-section, bonding the two layers together.

The technique allows the layered creation of a model that contains both external and internal details. The process continues until the entire body part has been generated – usually 18-24 hours depending on the part size and complexity. When the final layer is completed, the model is 96% polymerized. The model is finalized by placing it in an ultraviolet light chamber for approximately two hours.

Accuracy of the models improves every year and 3D Systems, Inc., claim the models have a 50-micron accuracy in the z-axis. The accuracy of these models has been verified clinically during multiple surgical procedures at Wilford Hall Medical Center.

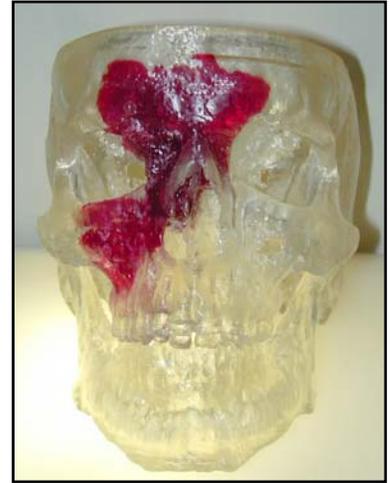


## Ordering Stereolithography Models With CT Data

Guidelines for submission of a stereolithography model from MacKown Dental Laboratory:

1. Provide an optical disk to the lab technician (Maxoptic or GE) with scan data on the disk.
  - a. Data can come from most any type of CT or MRI scanner. Lackland uses a GE Medical Systems High Speed Advantage CT apparatus and writes to a **WORM** (write once, read many) disk. Helical/spiral CT scans are usable, however, may not be as accurate as the conventional CT scans.
  - b. Data can also be submitted on CD-ROM if converted to an STL file format first!

- c. The software CANNOT read rewriteable optical disks.
2. Appropriately fill out all the information on a DD Form 2322. Please include Base Information, Phone Number and e-mail address.
3. Prescribe on the DD Form 2322 the work order requirements: what kind of model you want (Skull, Mandible, etc).
4. For dental implant studies, make sure the radiologist uses the radiographic template and a 0° Gantry tilt for each jaw scanned.
  - a. Scan parallel to the occlusal plane of the maxilla or mandible, depending on which jaw the implants are to be placed – this helps to eliminate scatter radiation generated by metallic dental restorations and minimize distortion from the opposing dentition.
5. When possible, scan 1mm slices in the area of interest, **NOT** 3mm slices reformatted to 1 mm. This is especially important in areas like the orbit, maxilla, and mandible.
  - a. For **Sim/PLANT** formats, areas of concerned must be scanned in **1 mm** slices!
6. For full skull models, increase the display field of view to 25” or more.
7. For 2-color sterolithography models, the scanner’s technique level may need to be increased to develop enough contrast between differing tissues types.
8. The final result is only as good as the data received. Feel free to contact us if you have any questions.



## Fabrication Times

For routine cases, the turn-around-time is 10-14 days from the time the data is received. Rush cases are possible in 2 –3 days, however, this depends upon the availability of the SL machine. Custom titanium devices fabricated on the SL models generally require 14 – 21 days, depending on the complexity of the device.



*Custom titanium distraction device*

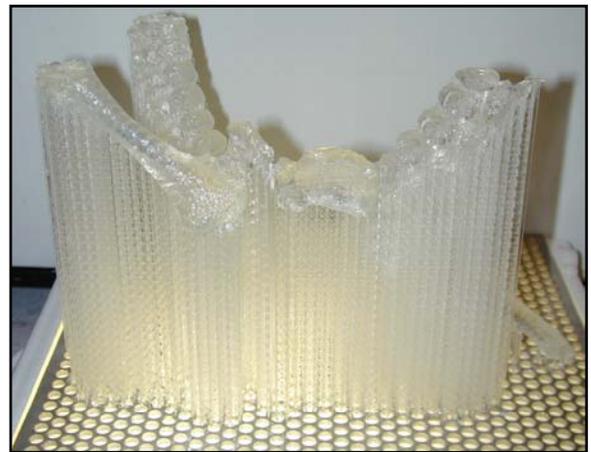
# Laser Scanners

The Stereolithography Laboratory has two laser scanners capable of scanning body parts and small items. The information from the laser scans can be submitted for stereolithography models, manipulated to make mirror images of body parts (i.e. eyes and ears), and used for maxillofacial prosthetic molds and facial moulages. Information can be gathered about color, surface texture, and shape. Other uses of this technology include studies of soft tissue changes following orthognathic procedures, racial facial characteristics, volumetric studies, and the fabrication of body part prostheses.



## Case Experience

Over 300 models have been fabricated by the Stereolithography Laboratory for the various WHMC Departments including: Plastics and Reconstructive Surgery, Otolaryngology, Neurosurgery, Oral and Maxillofacial Surgery, Maxillofacial Prosthetics, Pediatrics, Orthopedics, Prosthodontics, and Periodontics. Additionally, multiple case submission have been received from Travis AFB, Wright-Patterson AFB, Bethesda NS, and other DOD institutions. Multiple surgical cases have been preformed with the aid of this technology to include the separation of Siamese twins, the diagnosis and treatment planning of numerous craniofacial clefts, treatment of traumatic gun shot wounds, the fabrication of intraoral custom distraction osteogenesis devices, the placement of a custom titanium implant to replace the floor of an orbit, mandibular reconstruction cases and the fabrication of custom temporomandibular joints in a patient formerly considered non-reconstructible.



*Pelvic structure of conjoined twins*

# Summary

Anatomic models fabricated by stereolithography serve as an extremely valuable adjunct to conventional diagnosis and treatment planning. With the support of the MacKown Dental Laboratory, many custom devices can be designed and fabricated to support patient treatment. If you would like to learn more about these processes or the use of these models to date, feel free to contact us at the 59<sup>th</sup> Dental Squadron!



## Need Help?

For answers to questions, don't hesitate to call or email:

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