Digital Models : The future of Dentistry

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Introduction

At the beginning of the 20th century, plaster was the primary material used to capture dentofacial morphology. Almost all practitioners used this material to make casts of the teeth and alveolar bone. These dental casts, along with a careful clinical examination of the patient, formed the database for orthodontic diagnosis and treatment planning.

3D Digital Models

Although traditional plaster study models have been used for many years, they have many limitations. For one, plaster study models break. Continued use for measurements and display can wear away plaster, decreasing accuracy and increasing the likelihood of fracture. **Storage** is another concept presenting both space and time problems. Models are usually kept in boxes for easy retrieval while keeping them from physical and chemical damageThis might necessitate an off-site storage facility, increasing cost. Another problem is **portability**. Traveling with even a few sets of fragile study models is a difficult task. **Communication** is difficult when only one set of models exist. Digital models alleviate many of the obstacles encountered with using plaster models. They are not subject to physical damage and do not create any dust or other mess. They also require negligible storage space. The digital information for each case can be stored on an office computer's. **(Table 1)**

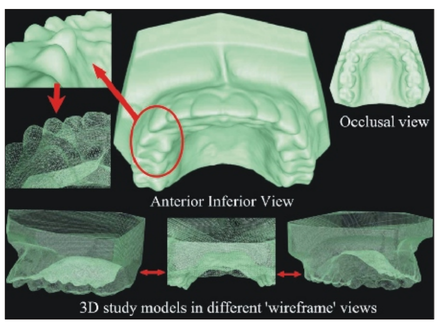
The electronic files in JPEG format contain all of the model information of numerous views of the models and can be transferred electronically to colleagues, specialists, and insurance companies. This decreases the time and expense of models duplication and shipment.

Digital models are also an excellent tool for patient education. The younger generation of patients currently in treatment are familiar with computers and are comfortable with computer-generated images. They can relate to digital models and probably expect to see this technology when they visit their orthodontists. Digital models can be shown to the patient and their guardians during treatment conferences, during treatment, and at the conclusion of treatment to illustrate the improvement in their dentition.

Various Techniques For 3-D Image Acquisition (3d Digital Models)

3d Laser Scanning

Intra-oral laser scanning may be difficult due to the possibility of patient movement during scanning, in addition to the safety issues related to the laser. On the other hand, laser scanning of study casts has many advantages over other scanning techniques, despite the long time of acquisition. Obviously, time of exposure is not an issue in this type if imaging. The problem of capturing the morphology of a study cast is related to the presence of many areas of undercut, not to its texture. This can be solved by capturing the study model from several different angles, which enables the production of a 360° model with a very high accuracy. Once the 3D model has been produced, the operator can save it in the hard disc of a computer in a specific 3D file format and the size of this file is dependent on the original resolution of the 3D mesh.



3D study models in different 'wireframe' views

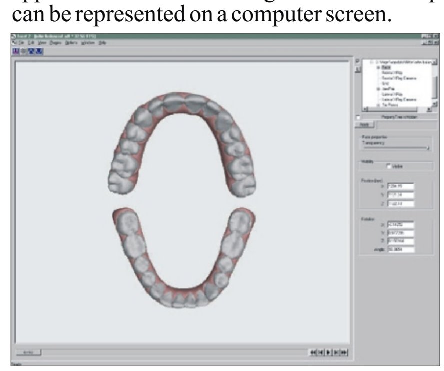
Destructive Scanning

Destructive scanning is a one of a number of methods used in engineering to assess the quality of electronic circuits by slicing them into component layers. By disassembling, testing, and inspecting a device, a complete profile can be created to determine how well a device conforms to design and process requirements.

For biologically trained observers like **orthodontists**, perhaps the best analogy for understanding destructive scanning is the **"serial section"** which we all remember from our earlier studies of histology and pathology. Recall that when we want to understand the 3D structure of a block of tissue in those disciplines, we invest the block after suitable preparation in a material of matched cutting properties and then make a series of slices with a microtome. The surfaces of the slices are then examined sequentially under a microscope and a 3D picture is constructed by mentally comparing the appearance of slices which lay and different depths into the block.

Procedure

In the destructive scanning of dental study casts, a carefully fabricated **white stone cast** is invested in **black epoxy plastic** of similar cutting properties. After the epoxy has set, the surface of the block is cut or milled until the first trace of white study cast appears. At that point, the 2D surface of the block is scanned with a flying spot laser scanner and the limits of the outline of the area of white study cast are mapped and stored in the computer. The entire surface of the block is then milled to a depth of approximately three thousands of an inch (~0.1 mm) and the process of laser scanning and 2D mapping is repeated. This process of slicing and mapping is repeated until the entire tooth-bearing portion of the cast has been milled and mapped. In place of a physical study cast, we now have a series of stackable computer stored 2D outlines from which a 3D virtual map of great accuracy can be generated as desired. Note that this method of serial slicing and scanning completely **eliminates the undercut problem**, which is such a major issue in many dental applications. The resulting virtual 3D map can be represented on a computer screen.



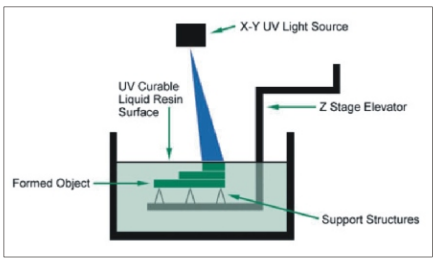
The virtual study casts can be manipulated, measured, or modified as desired on screen through the use of specialized software. Also, if desired, the virtual models can be used to regenerate

Table-1 Comparison of Plaster and Digital Models

	Plaster Models	Digital Models
Cost	Less Expensive	More Expensive
Diagnostic Setups	Laboratory Procedure	Virtual on Computer
Storage Space	Large Space Required	Negligible
Storage Costs	Costly	Negligible
Fast and Efficient Retrieval	Yes	Yes
Retrieval at Multiple Locations	No	Yes
Subject to Physical Damage	Yes	No
Transfer of Models	Laboratory Duplication and Shipping	Transfer of Digital File
Integration with office management software	No	Yes
Patient Education	Yes	Yes

physical 3D replicas of the original or of some desired modification of the original) using another new technology called stereolithography.

Stereo-lithography (SLA) is one of a number of new technologies for constructing 3D physical models from virtual 3D digital maps stored in computers. It uses a **photo-curable liquid resin** (either epoxy, vinyl-ether, or acrylate), which has the property of solidifying or "curing" when exposed to an ultra-violet beam from a **HeNe (helium-neon) laser**. The laser can be moved and positioned over a pool of the photo-curable liquid under the control of a computer file such as the 3D coordinate map previously generated during the course of the destructive scanning process. Thus, stereo-lithography offers us the ability to reconstruct a physical three-dimensional object from the virtual 3D computer map.



Although both technologies have become practical only in the last decade, variants of destructive scanning and stereolithography are already used in many industries.

Among their most rapidly growing applications is that in orthodontics where they are employed for different applications by both **Invisalign** and **Orthocad**.

3D CT scanning

3D CT scanning is another option, but its cost limits its usefulness in daily clinical practice. A validation of the process is required to estimate the error, since study cast stone is more radiodense than bone.

Stereophotogrammetry

Although this technique has proved to be very valuable in imaging human faces, it is not so suitable for capturing study casts. Ayoub et al. discussed the possibility of employing this technique to archive study casts in orthodontic practice and proposed a specific configuration of the system to achieve high quality models with an estimated accuracy of 0.2 mm.

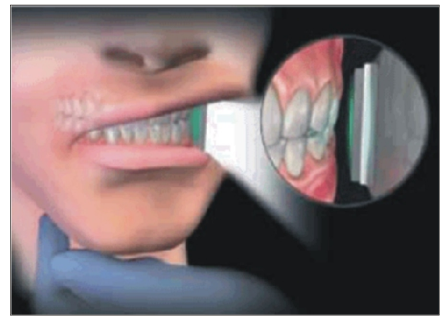
Intra-oral direct dental scanning OraScanner™ the first 3D hand-held intra-oral scanner, has been developed by OraMetrix Company in the USA, and depends on the structured light technique. A video camera records the structured light distortions on the dental crowns as it passes over the dentition in about one minute. The computer processes these images and merges them together to create a complete 3D dental arch.

Ora Scanner TM the first 3D hand-held intra-oral scanner, has been developed by OraMetrix Company in the USA.

While these forms of 3D data of the anatomy of the teeth are a great stride forward, there are limitations of not having the root, skeletal and soft tissue anatomy in three-dimensions. Some limited measuring capability is present and storage considerations are helpful, but the accuracy of manually measuring a 3D representation on the computer screen is still questionable.

Benefits to Clinicians and Labs

The greatest benefit for dental lab technicians and dentists in adopting digital technology lies in eliminating many chemical processes. By virtually eliminating these processes, error accumulation in treatment and in the manufacturing cycle is no longer an issue. Some of these processes are: curing the impression material, curing the plaster and base, curing the investment material in restoration dies, and retraction or shrinkage of conventional feldspathic ceramic materials. Furthermore, and particularly important in **orthodontics and orthognathic surgery cases**, taking checkbite impressions (centric occlusion) has historically been accomplished through the use of silicone materials or bite wax. When impressions are taken digitally, nothing is placed between maxillary and mandibular teeth. This dramatically reduces the risk of an inadequate interocclusal relationship.



Using the digital scanner to take a checkbite impression.

Conclusions

By addressing the everyday dental office issues described above, digital models , given its undeniable benefits, will be routine procedure in most dental offices in the coming years, And Patients will benefit from more comfort and a much more pleasant experience in the dentist's chair.

Since long before the Industrial Revolution men has handcrafted and manufactured millions of different products using analogical processes. In the last 30 years, many of these products have been converted to digital manufacturing-from auto parts to civil construction-given its consistent quality and lower cost. It is therefore no surprise that digital solutions are now being integrated into many dental procedures.

With the popularization of digital systems, and the tremendous growth in two areas of dentistry that can potentially benefit from digital models **(orthodontics and dental implantology)** one can confidently predict that in the coming years we will witness a true digital revolution in the dental office. A revolution that will benefit patients in terms of more efficient planning , reduced discomfort and treatment efficiency.

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