Research Article

Awareness of stereolithography among dental students

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ABSTRACT

Aim: This study aims to assess the knowledge about stereolithography (SLA) and its applications among dental students. **Introduction:** Computers can now be used to create accurately detailed projects that can be assessed from different perspectives in a process known as computer-aided design (CAD). To materialize virtual objects using CAD, a computer-aided manufacture (CAM) process has been developed. To transform a virtual file into a real object, CAM operates using a machine connected to a computer, similar to a printer or peripheral device. In 1987, Brix and Lambrecht used, for the 1st time, a prototype in health care. In 1991, human anatomy models produced with a technology called SLA were first used in a maxillofacial surgery clinic in Vienna. **Materials and Methods:** This study included 112 subjects. A questionnaire containing six questions was framed and survey was conducted using "SURVERYPLANET." Results were obtained and tabulated. **Results:** The obtained results showed that only 24% of dental students were aware of SLA and its applications. **Conclusion:** This study concludes that there is not enough awareness about SLA and its uses among dental students and that it should be used more frequently considering its advantages.

KEY WORDS: 3D Fabrication, CAD-CAM, Stereolithography

INTRODUCTION

A 3D reconstructions from high-resolution multiplanar imaging techniques such as computed tomography (CT) and magnetic resonance imaging (MRI) are well established.[1] These techniques have found applications in radiotherapy and for surgical planning, particularly in the craniofacial and maxillofacial fields and for neurosurgery.[2] Systems provide interactive functions which allow the surgeon to experiment with cutting and moving bony materia1 as such systems may also be used to obtain measurements for customized prosthetic implants, often designed by mirroring of the unaffected side.[3] There are occasions when three-dimensional(3-D) viewing may be inadequate and the surgeon would prefer to be able to handle a physical where the procedure is complex, the anatomy unusual and difficult to visualize on screen or the model when planning a procedure.

Physical models are also useful as molds for the fabrication of customized implants. Early models were built using milling techniques', but a significant limitation of such methods is the need to avoid undercuts.[5] This means that it is impossible to produce models with certain complex geometries where parts of the objects obstruct the access of the milling tool. The advent of rapid prototype technologies overcame these problems.[8] Rapid prototyping is used to describe the customized production of solid models using 3-D computer data and has resulted in fabrication technologies such as stereolithography (SLA, the first rapid prototyping technique), fused deposition modeling (FDM), and, more recently, selective laser sintering (SLS).[6]

At present, SLA technology is the most popular rapid prototyping (RP) technology applied in the field of maxillofacial prosthetics and has demonstrated significant advantages. There are several techniques, each of which builds up a model layer by layer.[11] These include laminated object manufacture (LOM), SLA, and SLS. Laminated and object manufacturing laminate thin sheets of material such as paper, after each layer is attached a laser is used to cut and remove unwanted areas. The result is a physical model. In SLA, the object is built layer by layer

Access this article online	
Website: jprsolutions.info	**ISSN:** 0975-7619

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Received on: 05-12-2018; Revised on: 07-01-2019; Accepted on: 10-02-2019

by the polymerization of selected regions of a tank of UV sensitive resin, resulting in a translucent model. The polymerization is performed selectively, using a laser to illuminate an area defined from CT data.[14] Each layer fuses to the one below, allowing the creation of the complex type of structure not achievable by milling. Software is available to generate support structures for regions of the object such as overhangs which need supporting during the build. These structures are removed once the model is complete.[16]

SLA models have been shown to have a precision for human skull models are used in oral and maxilla-facial surgery planning. SLS also involves the selective use of a laser to build up a model layer by layer. The material used is a fine powder (at present, nylon, polycarbonate, or wax) whose particles adhere and solidify (or sinter) under laser illumination.[18] SLS has the advantage over SLA that support structures are not required, as the unsintered powder provides support during the build. SLS models are opaque, and the development of materials is an area of strong current research interest. Powders which give a metal modeling or are biocompatible, such a hydroxyapatite is under research and development. However, a major disadvantage of SLA technology is that it can only fabricate resin prototypes of facial prostheses, which cannot be directly used for laboratory processing.[4]

MATERIALS AND METHODS

This study was conducted at Saveetha Dental College, Chennai, India, which included undergraduate students. While the intent was to maximize the awareness of stereolithography, survey was conducted on “SurveyPlanet” and circulated among students. A six questions survey was distributed to 150 students in which 112 students attended the survey. The questionnaire is yes-no questions and other self-explanatory questions. The subjects were administered with a structured questionnaire about the awareness and uses of stereolithography. Data received were decoded, tabulated, and recorded in an Excel database, and analyzed using the Statistical Package for the Social Sciences (IBM SPSS) software.

RESULTS

The obtained results were recorded in an Excel database and analyzed using the Statistical Package for the Social Sciences (IBM SPSS) software. 76% of the 112 subjects have answered that they were not aware of SLA [Figure 1]. 85 subjects were not aware of the applications of SLA such as mock-up surgeries, facial prosthesis, and splints [Figure 2]. All the 112 subjects agreed to that SLA (3D printing) can be used as prosthetic treatment modalities in maxillofacial traumatic injuries and facial reconstruction [Figure 3]. 88% of the subjects were not aware of the types of stereolithography. The types are nine basic types of 3D printing technology currently exist include FDM, SLA, digital light processing, SLS, selective laser melting, electron beam melting, LOM, binder jetting, and material jetting/wax casting [Figure 4]. The three most common are SLA, FDM, and SLS. 67 students were aware that mock-up surgeries can be performed on prototypes created from stereolithography [Figure 5]. 95% of the subjects opted SLA over custom fabrication of facial prosthesis [Figure 6].

DISCUSSION

Medical rapid prototyping is defined as the manufacture of dimensionally accurate physical models of human anatomy derived from medical image data using a variety of RP technologies.[2] Some RP machines had already been in experimental use in the 1970s, and CT was invented in the 1960s by Godfrey N Hounsfield, an electronics engineer, in collaboration with Allan McLeod Cormack, a physicist. However, it was only in the 1990s that an actual 3-D model was built to reproduce the anatomy of a patient based on CT images obtained during that patient’s examination, thanks to advances in CT scanner quality and the development of specific software for this purpose. RP has been applied to a range of medical specialties including oral and maxillofacial surgery, dental implantology, neurosurgery, and orthopedics.

Complex diseases in medicine often demand time-consuming surgery. Surgical planning tries to minimize the duration of surgery to reduce the risk of complications. In addition to the normally used imaging modalities, 3-D visualization techniques can be applied for supporting the planning process. Such visual representation of medical objects allows simulation of surgical procedures before surgery. The greatest advantage of RP technologies is the precise reproduction of objects from a three-dimensional medical image data set as a physical model which can be looked at and touched by the surgeon.[4]

Medical rapid prototyping is also being developed for use in dental implants. Greater accuracy was achieved with the use of rapid prototyped surgical guides for creating osteotomies in the jaw, and a computer-assisted design/computer-assisted manufacture (CAD/CAM) approach to the fabrication of partial dental frameworks has been developed.[5]

Using state-of-the-art CAD/CAM technology, the two normally separate processes of bracket production and bracket positioning are fused into one unit. In

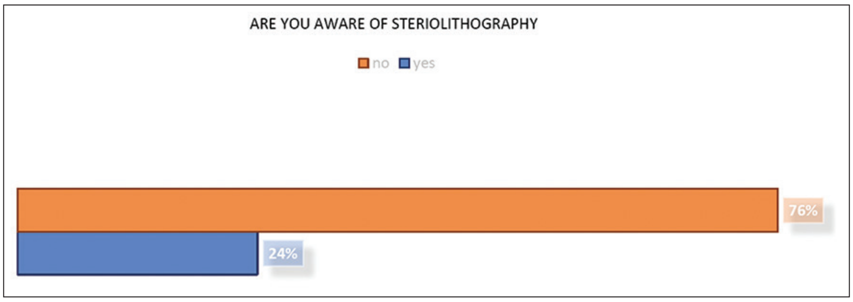

Figure 1: Awareness of stereolithography

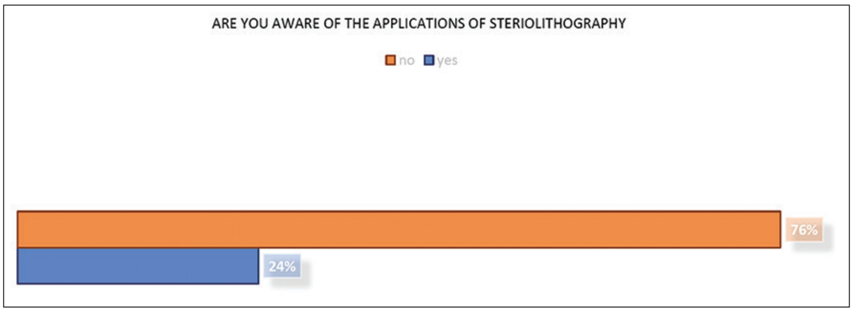

Figure 2: Applications of stereolithography

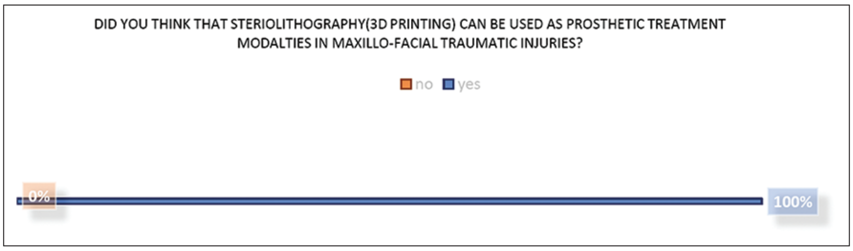

Figure 3: Prosthetic treatment modalities

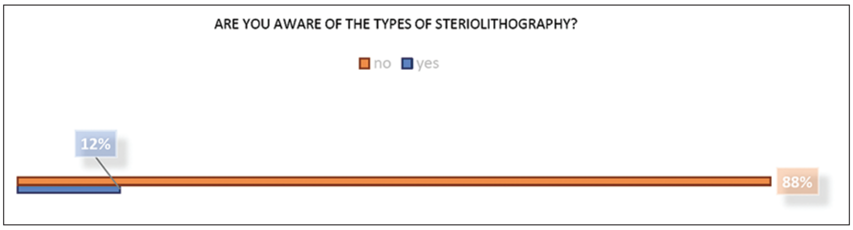

Figure 4: Types of stereolithography

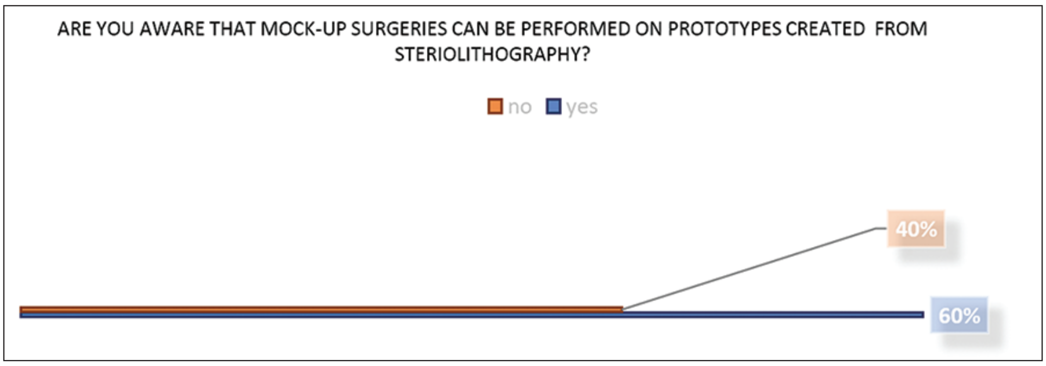

Figure 5: Surgical prototypes

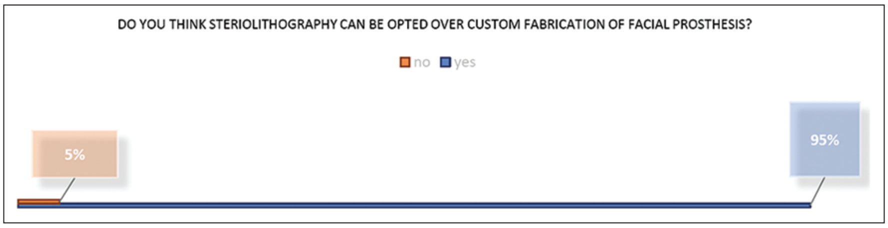

Figure 6: Stereolithography over custom fabrication

this process, the demand for maximum individuality with simultaneously minimized space requirements is put consistently into practice.[8] Another innovative use of the CAD/CAM technology was to create an overcrown able to open the bite through clinical crown lengthening of the mandibular second premolars. Some technology provides clear plastic orthodontic treatment devices. Everyone to 2 weeks, the patient receives a new set of splint-like aligners that are intended to continue moving their teeth.[9] This technology utilizes several SLA machines to fabricate models on which plastic sheets are molded. Data sets are obtained by digitizing an impression taken of the patient's teeth. The resulting point sets are separated into individual tooth geometries, which are then positioned according to the orthodontist's treatment plan.

Anatomic medical models built with RP technologies represent a new approach for surgical planning and simulation. These techniques allow one to reproduce anatomical objects such as three-dimensional physical models of the skull or other structures, which give the surgeon a realistic impression of complex structures before surgical intervention. The shift from the visual to the visual-tactile representation of anatomical objects introduces a new kind of interaction called "touch to comprehend."[9] Clinical data indicate that computer-aided RP may be of value in minimizing the extraoral time and possible injury to transplanted teeth during the process of autotransplantation.[10]

Since the advent of osseointegration, the use of dental implants has evolved rapidly over the past decade. Research in the field of oral implantology has led to refinements resulting in highly successful and predictable restorative options for partially as well as completely edentulous patients; however, improper implant placement can have a profound and often detrimental effect on the long-term predictability and success of the implant-supported prosthesis.

The use of CAD/CAM technology has gained popularity in implant dentistry. The applications pertain to three-dimensional imaging, 3D software (Delcan India, Maharashtra) for treatment planning, fabrication of computer-generated surgical guides using additive RP, as well as fabrication of all-ceramic restorations using subtractive RP.[12] RP technology allows for industrial fabrication of customized three-dimensional objects from CAD data.[7]

The absence of all or part of the external ear may be either acquired or congenital. When attempting to restore this part with prosthesis, the prosthesis should ideally be customized to restore the anatomy as closely as possible. In so doing, it may be helpful to have *a priori* knowledge of average values for each index and use these values to help construct prosthesis of the appropriate size and shape.[13] However, individual proportion indices vary from the average, so where the defect is unilateral, it is more practical to compare and duplicate proportions from the non-defect side.[14] This process can be difficult and time consuming and demands a high level of artistic skill to form a mirror image and achieve a good esthetic match. Similarly, patients with existing prostheses may need frequent replacements due to color changes, loss of fit, tearing, aging, contamination of the material, and general wear.[18] Conventional duplication procedures are often unreliable and inaccurate, as errors may occur at any one of many stages during production.[16]

The advent of CT and MRI with three-dimensional representation of human anatomy has opened up new perspectives for design and production in the medical field computer manipulation of the data allows for mirroring or modifications to establish the exact dimensions needed, and a computer numeric controlled (CNC) milling machine can be used to manufacture a template for the final prosthesis. CNC milling, however, is limited by difficulties encountered when trying to replicate the complex anatomy of internal features.

The development of RP systems has led to the creation of customized three-dimensional anatomic models that exhibit a level of complexity unknown with CNC-based equipment, primarily because RP methodologies use an additive process of building an object in layers defined by a computer model that has been virtually sliced.[4] This allows for the production of complex shapes with internal detail and undercut areas. One such method is SLA, which produces three-dimensional objects by curing a liquid resin under a computer-guided laser. A newer system is the Thermojet Printer (3D Systems): Shenzhen Towell Model Technology Co., Ltd., Shenzhen, China, which operates as a network printer and uses wax as the building material. The advantage of such a system is the ability to cast directly from a wax model.[16]

CONCLUSION

In this study, among dental students, the results were quite evident that 76% were not aware of stereolithography and its uses. Considering all the advantages of it, it should be used more frequently in the field of prosthodontics, maxillofacial surgery, implant planning, and orthodontics.

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Source of support: Nil; Conflict of interest: None Declared