THE APPLICATION OF RAPID PROTOTYPING (RP) IN THE MEDICAL AREA: PROCESS AND CLINICAL BENEFITS

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Abstract. *The application of computation and manufacturing methods on diagnosis and treatment of complex surgical cases are, sometimes, decisive for clinical success. The use of Rapid Prototyping (RP) in medical area has allowed to obtain tridimensional models that represent the exact anatomic structure of the patient. The main systems are: Stereolithography (SL), Selective Laser Sintering (SLS) and Fused Deposition Modeling (FDM). Surgeons are using biomodels to plan surgeries, diagnose diseases and simulate surgeries. The aim this work is describe the main systems and show their benefits in clinical cases.*

Keywords: *Rapid Prototyping, Biomodel, Medical Area.*

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1. INTRODUCTION

The technology provided by informatization in manufacturing prototypes or models in short periods of time, is no doubt among the greatest advances of modern age. For this reason, this technology is known as Rapid Prototyping, in contraposition to traditional methods that delay weeks or months. Such methods are very peculiar, once they aggregate and link materials, layer by layer, to compose the desired object. They offer several advantages in many applications when compared to classic manufacturing processes based on remotion of material, such as milling and turnery.

Binder at al. declare that stereolithografic models have been more and more used in industry to design components in several apllications, including automobiles, aircrafts and computers. Recently, this technique has been applied in medicine, mainly to create replicas of skeletal structures, by tomography mapping, to aid surgeries of the maxilofacial complex, orthopedic surgeries and procedures to create osteosynthetic grafts with precise adaptation.

Belgica was pioneer in developing medical models. The technology disseminated to countries such as France, Germany and United States, where became stronger and from were spread with celerity.

This technology generates benefits in craniofacial and maxilofacial surgeries and otorrinolaringology.

2. RAPID PROTOTYPING SISTEMS

The main rapid prototyping sistems used in manufacturing models are:

2.1. Stereolithography (SL)

The Stereolithography is based on polimerization of a photosensitive resin (acrilic, epoxy or vinil) by a beam of UV laser (ultraviolet). The SL machine contains a tub that is fulfilled with resin and inside the tub there is a platform that moves from top to bottom. A source of UV laser with high focus precision, form the first layer hardening the transversal section of the model and leaving liquid the remaining areas. After this, an elevator lightly dives the platform inside the bath of liquid polymer, and the laser creats a second layer of solid polymer on the first layer until complete the prototype. This tecnology allows the acquisition of transparent resin models.

2.2. Selective Laser Sintering (SLS)

In the SLS process, a thin layer of powder fused by heat is settled on a surface with the aid of a roller. A beam of CO_2 syntethizes the selected areas, eliciting the adherence of the powder on the areas to be formed by the part in that particular layer. Consecutive lodges are performed until the part is completed. The diversity of materials that can be used is significant when comparing to other processes. Some materials avaliable to SLS are wax, polyamide, elastomer, ceramic, coin and others.

2.3. Fused Deposition Modeling (FDM)

Fused deposition modeling creats the model by extrusion and hardening of a warm thermoplastic material filament The wire designed to the model are of ABS, elastomer or wax. A extrusion nozzle moves on the horizontal plane, continuously settling the extruded material, creating the layers of the part. The FDM models can be sterilized and show good dimensional precision.

3. PROTOCOL TO OBTAIN PROTOTYPES

The image selection depends on the anatomic region of interest. Therefore, the patient is directed to a computed tomography (CT) or magnetic resonance (MR) examination, according to the purpose of reproducing soft or hard tissues. The images must be obtained in axial slices, using preferably last generation devices, such as helicoidal tomographs. Besides exposing patients to a low radiation level, the helicoidal tomograph increases the precision of image and may generate slices of up to 0.6 mm. Manufacturing a model, only the axial 2D slices are important (Fig. 1).

Figure 1 - Axial slices for making of the maxillary model in 3D.

Usually, axial slices of 1.0 mm thickness are make and, after piling, generates a 3D model. The 2D images are recorded in one of the physical midia: CD-ROM, 8 mm DAT tape, Optic Disc 5.25”, diskettes, Zip Drive and directed to the Biomedical Prototyping enterprise that will manufacture the prototype (Fig. 2).

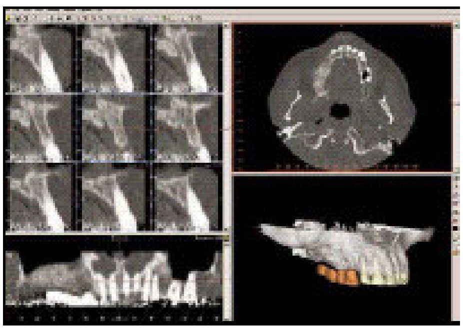

Figure 2 – Virtual positioning of surgical guide.

The cost of the model is calculated according to the volume of parts, raw material and system used. Therefore, depending on the object, it can be reproduced only one part of the desired organ, in order to reduce the costs.

4. CONSIDERATIONS AND CLINICAL APPLICATIONS

According to MEYER et al, guided by graphic technology and CAD/CAM, individual bone structures may be constructed out of the body. The high degree of fidelity allows presurgical avaliation, surgical planning and simulation and stimulation techniques, as well a guide to create personalized fulfilling prosthesis (Fig. 3, Fig. 4). The acrilic model can be sterilized to be used in surgical rooms as an aid model to surgeons.

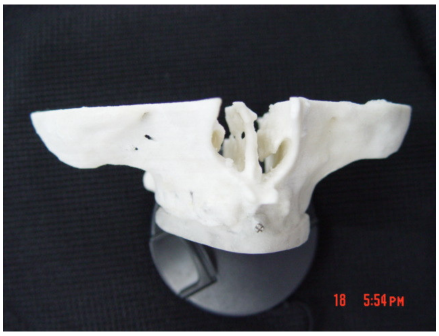

Figure 3 –Stereolithography model.

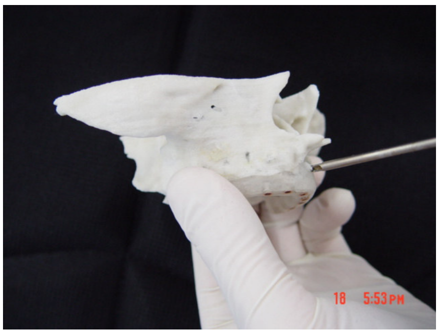

Figure 4 - Surgical planning.

The model allows surgeons to visualize the precise location of incisions or positioning of screws. These models has allowed excellent presurgical evaluation, patient´s understanding about treatment, repair of cleft palate and otorrinolaringologic, maxilofacial and orthopedic surgeries.

5. DISCUSSION

The abundant literature is unanimous in exalting the great advantages of Rapid Prototyping and to show, with almost the same unanimity, one disadvantage – its high cost. So that, its difusion and democratization has been promoved in order to bring beneffits to humble people. With this aim, it will be proposed to Health Ministry the introduction these techniques in hospitals, by the Sistema Único de Saúde (SUS).

Stoker, Mankovich and Valentino affirm that the stereolitografic models manufactured by digital data allow the professional to visualize internal and external anatomy of his patient before surgery.

Stereolitografic models allow tactile perception of the region anatomy and pathology studied; making possible the corroboration of informations obtained from imaging diagnosis and offer other several advantages, such as communication between surgical staff, patients and their relatives, simulation and surgical planning, manufacture of personalized implants and criterious proservation.

According to Sales, Anchieta and Carvalho, the interaction professional-patient is closer with this technique because allows visualization of anatomic structures, locations of tumors or any other lesions, providing better understanding of the reality and complexity of patient´s problem, making easier the enlightenment of his patology and the surgery to be executed to his treatment. Even the use of a conventional model would have not the same significance as to handle his own pesonalized model. Therefore, prototypes are excellent preoperative anatomic references and are parameters to posterior comparizon, what is very important in cases of squeletal intervention, as in dental surgeries, specially orthognatic ones. The manufacture of personalized implants to bucomaxilofacial surgery reconstruction is, no doubt, one of the greatest advances offered by Rapid Prototyping.

6. CONCLUSION

This recent and promising technology allows a decrease in surgical time and obtention of high rates of success in surgical approachs.

The solid replica of patient´s anatomy greatly simplify the surgical practice, helping diagnoses, planning, surgical simulation, manufacturing of personalized implants and proservation.

The model helps comunication between professionals and patients, allowing better comprehension, clear and adequate information about the focused entity.

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