FABRICATION OF HUMAN EXTERNAL EAR BY USING 3D PRINTING

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Abstract: The conductive hear loss due to ossicular abnormalities occurs from many causes, including trauma, cholesteatoma, infection, surgery and congenital anomalies. In case of any injury or accident the person may lose an ear or cut off from the head. Both understanding and reconstructing its functions has always been an important topic for researchers from medical and technical back ground. Recent advances in the fields of tissue engineering and 3d printing promise to profoundly affect the practice of reconstructive surgery. Therefore, we have built a human external ear prototype by using the 3D printing technology from the CT scan by conversion using 3D slicer software.

Firstly, a collection of a human head computer tomography (CT) scanned file of DICOM data format is done. Then the DICOM data file is imported and converted into NRRD file format by using 3D slicer software and saved in a folder. Then the NRRD file is converted into 3D printable STL file format after slicing of external ear from head. The sliced part of ear is saved as STL file in a folder. Then the STL file of the ear is imported into the 3d printing machine which builds the prototype of ear. During the prototype building, various parameters of printing machine are recorded. After the completion of prototype formation, surface finishing is done by taking out of the machine. This study also includes the applications of technology of present and future in biomedical area which is used in this project for the fabrication of human ear.

Index Terms - ossicular, Trauma, Infection, Standard Triangular language, surgery, Tissue engineering**,** Biomedical, prototype, fabrication.

I. INTRODUCTION

Knowledge of the normal ear morphology is important in the treatment and management of variety of congenital deformities such as trauma, cholesteatoma, infection, surgery and congenital anomalies etc. Also, its subtle structures that shows potential signs of age, gender and aesthetic appearance. Reisberg et. al [1] has reported the importance of ear rehabilitation for facial aesthetic. Previous methods applying hand sculpturing, impression of similar ear for mirror imaging and wax modeling for ear reconstruction. However, these traditional methods face a lot of challenges in producing the correct anatomic morphology, as it is time consuming and involved massive laboratory work. Moreover, the impression technique causes deformation and discomfort to the patient. It's also contributed to inaccuracy in producing the prosthetic ear. Coward et al [2] has utilized a technique using stereo photogrammetric imaging to produce accurate ear prosthesis. Result from this study indicate that stereo photogrammetric showed some significant errors in their result. This could be due to limitation of locating anatomical landmarks especially bony landmarks. Furthermore, another method applying laser scanner have certain disadvantages such as high cost and need proper training [3]. These multi-modality imaging techniques play an important role in data capturing. However, not many studies utilized computed tomography scan (CT scan) data for ear reconstructions applying computer reconstruction algorithm. With the marriage of computer imaging technology and advanced manufacturing, recent studies indicate that computer aided design and computer aided manufacturing (CAD/CAM) can overcome the above problems [4,5]. Therefore, the aim of this research is to utilize this technology of medical imaging and additive manufacturing to custom fabricate ear prosthetic for ear reconstruction and rehabilitation.

1.1 CAD/CAM AND ADDITIVE MANUFACTURING FOR PROSTHETIC EAR FABRICATION

Recently, additive manufacturing technology has been introduced in the biomedical field for fabrication of models to ease surgical planning and simulation in implantology, neurosurgery and orthopedics, as well as for the fabrication of maxillofacial prostheses [7]. Additive manufacturing is a technique that represent a set of additive technologies based on the construction of physical three-dimensional structures, layer by layer, based on its respective digital models. This technology can produce complex shapes such as cavities usually present in human anatomy. Currently, there are various numbers of additive manufacturing technologies available in the market, based on special sintering, layering or deposition methods. Some of the famous technologies are Stereolithographic (SLA), Selective Laser Sintering (SLS), Fused Deposition Modeling (FDM), Laminated Object Manufacturing (LOM), 3D Printing. Among of these technologies, SLA is the leading technology with over 500 SLA machine installed worldwide [8]. It's developed by 3-D Systems Inc, of Valencia, CA. The SLA 7000 system is two times faster, on average, than the next fastest solid imaging system from 3D systems. Its system's 0.0254 mm layer thickness yields a smooth finish that result in far less post-processing time. The study conducted by Jiao et al. reported that fabrication of ear prostheses using CAD/CAM was advantageous because a highly qualified technician is not necessary to sculpture an ear in wax [4]. The procedure can be carried out in a computer and patient can visualize the result at the screen before fabrication. Subburaj et al. also demonstrated the method of fabricating the auricular prosthesis using CAD/CAM and rapid prototyping technologies [9]. The result showed that the computer aided method gave a higher level of accuracy in terms of shape, size and position of the prosthesis, and significantly shorter lead time compared to conventional technique**.**

1.2 CLINICAL REPORT

The first stage in the fabrication of the prosthetic ear is to capture the data of the ear digitally. There are various techniques to capture the data either mechanical scanning devices or optical scanning devices. In this research, data was captured using medical imaging technique. The person who had traumatic incident that caused 90% of her face was damaged due to acid was studied. He totally lost her right ear in the incident. Doctor planned to do facial reconstruction to help her facing her trauma. One of the plans was to

reconstruct her right ear. he had undergone CT scan procedure after the incident. As for this case, the data is retrieved from CT scan images. Data captured using CT scan gave stack of images in 2-dimensional (2D) form. All these images need to be converted to 3 dimensional (3D) images for further designing the ear.

1.3 3D PRINTING

3D printing can create physical objects from a geometrical representation by successive addition of material. 3D printing technology has originated from the layer by layer fabrication technology of three-dimensional (3D) structures directly from computer-aided design (CAD) drawing. 3D printing technology is a truly innovative and has emerged as a versatile technology stage. It opens new opportunities and gives hope to many possibilities for companies looking to improve manufacturing efficiency. Conventional thermoplastics, ceramics, graphene-based materials, and metal are the materials that can be printed now by using 3D printing technology. 3D printing technology has the potential to revolutionize industries and change the production line. The adoption of 3D printing technology will increase the production speed while reducing costs. At the same time, the demand of the consumer will have more influence over production. Consumers have greater input in the final product and can request to have it produced to fit their specifications. Nowadays, 3D printing is widely used in the world. 3D printing technology increasingly used for the mass customization, production of any types of open source designs in the field of agriculture, in healthcare, automotive industry, and aerospace industries. At the same time, there are several disadvantages the adoption of 3D printing technology in manufacturing industry. For instance, the effect of the use of 3D printing technology is will reduce the use of manufacturing labour so automatically will greatly affect the economy of countries that rely on a large number of low skill jobs. Furthermore, by using 3D printing technology, users can print many different types of objects such as knives, guns and dangerous items. Therefore, the use of 3D printing should be limited to only certain people to prevent terrorists and criminals bring guns without detected. At the same time, the people who get a hold of a blueprint will be able to counterfeit products easily. This is because, the use of 3D printing technology is simple, just sketching, and set the data in the machine-printed so 3D objects can generate. To sum up, 3D printing technology has emerged during recent years as a flexible and powerful technique in advance manufacturing industry. This technology has been widespread used in many countries, especially in the manufacturing industry. Therefore, this paper presents the overview of the types of 3D printing technologies, the application of 3D printing technology and lastly, the materials used for 3D printing technology in manufacturing industry.

II LITERATURE REVIEW

1. **Elisa mussi and et.al** They aim to describe and analyses the different materials and methods adopted during the history of autologous ear reconstruction (AER) simulation to train surgeons by practice on geometrically and mechanically accurate physical replicas. Recent advances in 3D modelling software and manufacturing technologies to increase the effectiveness of AER simulators are particularly described to provide more recent outcomes.
2. **Yahui Liu and et.al** They presented a paper which is about novel 3D ear imaging system, which can acquire high quality 3D ear images in real time. The main components of our 3D ear scanner are CCD camera, laser projector, step-motor, photoelectric encoder and motion control circuit. The laser-triangulation principle is used for the 3D image reconstruction. The architecture of the system and its calibration are discussed. The system is designed to have good performance at a reasonable price so that it is suitable for civilian personal identification applications. The experiments show that the developed 3D ear acquisition system can obtain effective 3D information from an ear. At the end, we have constructed a large 3D ear image database which can be used for future feature extraction and performance analysis in later work.
3. **Gordon M. Paul and et.al** This is a review of some of the recent developments in the application of 3D printing to medicine. The topic is introduced with a brief explanation as to how and why 3D is changing practice, teaching, and research in medicine. Then, taking recent examples of progress in the field, we illustrate the current state of the art. This article concludes by evaluating the current limitations of 3D printing for medical applications and suggesting where further progress is likely to be made. In this the categories of medical applications to classify existing research into 3D printing in medicine are surgical planning, prosthesis, medical education and training, medical research, organ printing, drug delivery.
4. **Ibrahim T. Ozbolat and et.al** Organ printing, which is defined as computer-aided additive bio fabrication of 3-D cellular tissue constructs, has shed light on advancing this field into a new era. Organ printing takes advantage of rapid prototyping (RP) technology to print cells, biomaterials, and cell-laden biomaterials individually or in tandem, layer by layer, directly creating 3-D tissue-like structures. Here, we overview RP-based bioprinting approaches and discuss the current challenges and trends toward fabricating living organs for transplant in the near future.
5. **Zengmin Xia and et.al** This review discusses the state of the art of the technology, along with a broad range of biomaterials used for 3D bioprinting. It provides an update on recent developments in bioprinting and its applications. 3D bioprinting has profound impacts on biomedical research and industry. It offers a new way to industrialize tissue bio-fabrication. It has great potential for regenerating tissues and organs to overcome the shortage of organ transplantation.

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