Hybrid Workflow for Fabrication of Auricular Prosthesis Utilizing Medical CT Scans

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Patient's Chief Complaint

Patient expresses concern about a defective-looking right ear and would like to have a prosthesis to restore aesthetic appearance.

Patient's Facial Status

Facial asymmetry with near-total loss of the right ear and a small remnant remaining as presented in Figure 1. Exposed bone is present posterior to the remaining remnant.

Treatment Plan Summary

Fabrication of a removable adhesive retained auricular prosthesis to restore structural continuity in addition to enhancing the patient's self-esteem, social reintegration, and reducing the distress of losing a facial structure. This workflow aids in fabricating facial prostheses in a time-efficient manner, minimizing chair-side time, while duplicating the anatomy of the contralateral ear by utilizing the patient's existing medical computed tomography (CT) scan and three-dimensional (3D) printing technology.

Pre-treatment Photographs (Figure 1)

Details of Therapy

The treatment plan for this patient involves fabricating a silicone auricular prosthesis that will be adhered over the misplaced remnant. A summary of the workflow is described in Figure 2. The majority of head and neck cancer patients have CT scans taken at multiple stages throughout the process of diagnosis, treatment, and post-treatment. Before the patient's appointment, certain selected data is extracted in the digital imaging and communications in medicine (DICOM) format from the patient's CT scans that are present in the Picture Archiving and Communication System (PACS). The data is then uploaded to InVesalius 3, which is free, open-source software for reconstructing computed tomography. Once the data is in the software, the predefined/manual threshold for the tissue type we are interested in is selected. In this case, it is the skin tissue (adult). From here, a digital impression is obtained, and the file is exported in Standard Tessellation Language (STL) format. These digital scans are good at capturing soft-tissue landmarks. The STL files are then uploaded to Meshmixer, a free, powerful software designed for editing, repairing, and optimizing 3D mesh models. The anatomical area of interest, in this case, the contralateral healthy left ear, is selected, and the remaining data is deleted by selection or by separating unwanted shells to allow for a reduced file size. The scans can then be edited more precisely. This allows exporting mirror images to obtain the adjusted orientation of the healthy ear to the defective one.

From there, models are created on the software by adding a thicker base that can be printed with a 3D printer. FormLabs 2 (FormLabs, Somerville, MA) was the printer used in this case. It utilizes laser-based stereolithography (SLA) technology that cures liquid resin into a solid. The STL files are loaded onto the printer's building platform, and the model is 3D printed. Once the physical model is ready, it is duplicated in alginate and poured with sculpting wax to be used as the customized base wax pattern for the prosthesis.

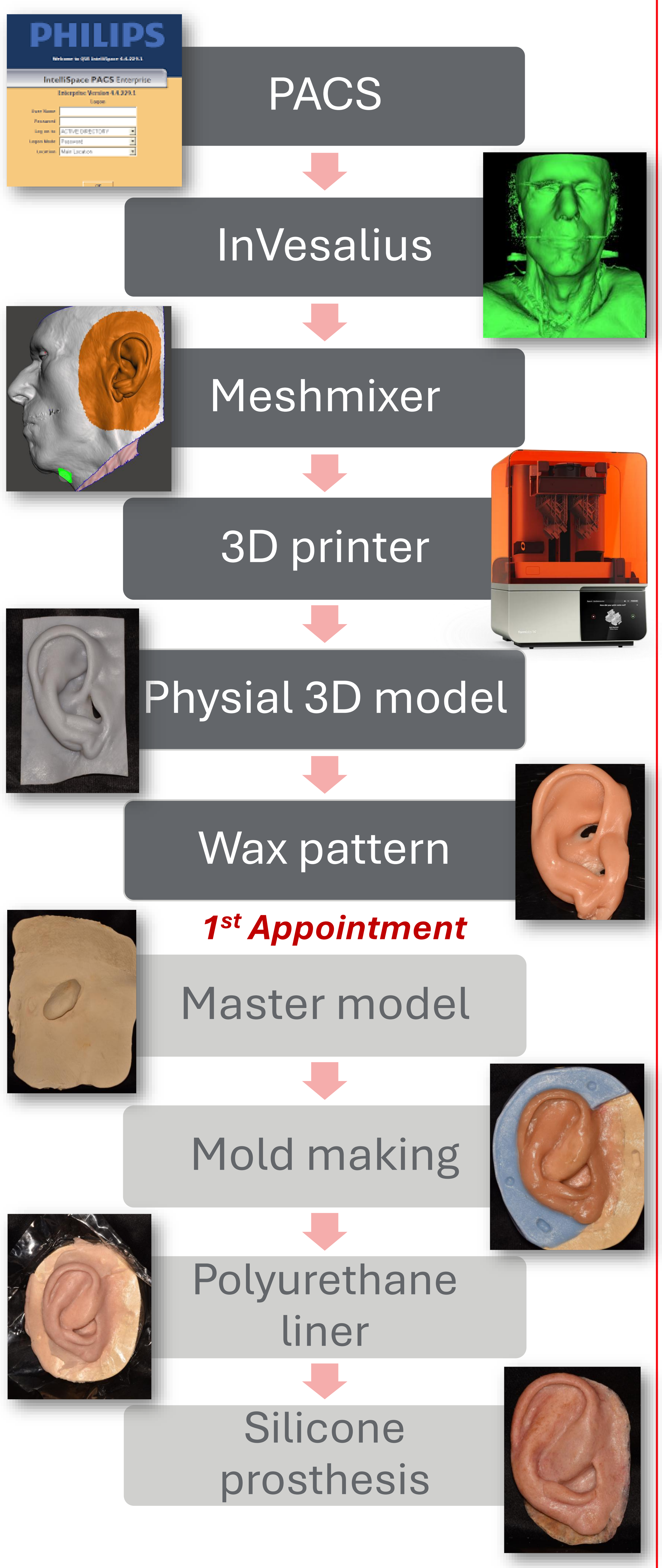


Figure 2. Flowchart discussing the sequential steps in following this hybrid workflow.

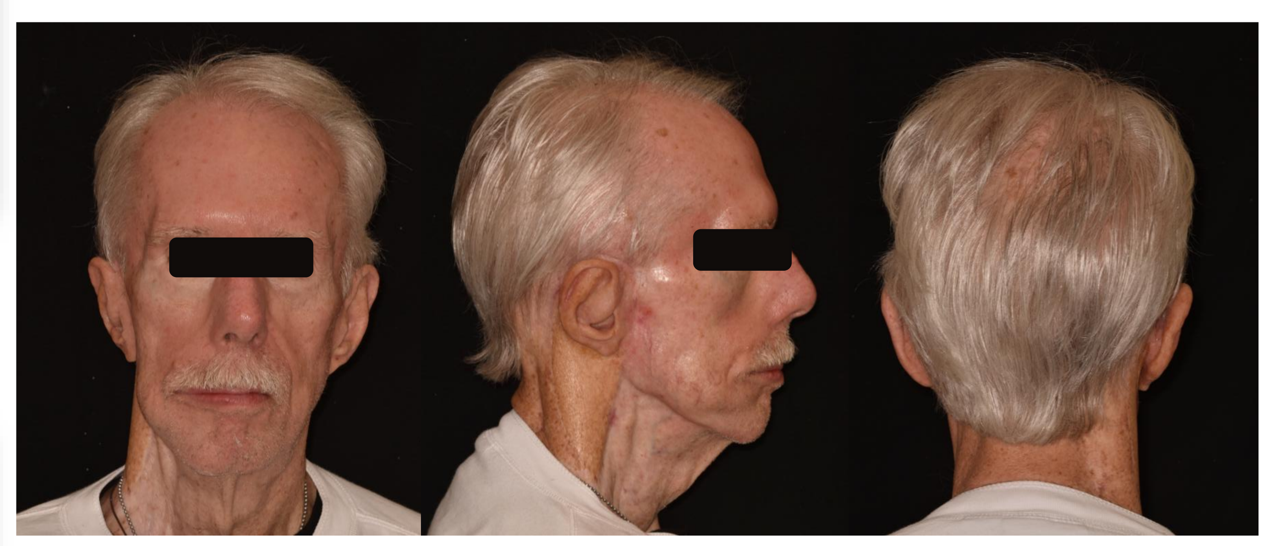
During the patient's first visit, an impression of the defect is made, and it is poured with ivory rock stone. After the model sets, slight buffing of the movable surfaces is done, then a layer of 0.002 tin foil is cut appropriately, and the wax pattern is adjusted and positioned roughly to try on the patient.

Visual evaluation, photographs, and Photoshop are utilized to aid in positioning the wax in a proper spatial orientation and anatomical alignment in comparison to the contralateral intact ear. Once the wax pattern is finalized in accordance to symmetry, marginal integrity, esthetics, and surface texture, molds are fabricated in three parts to allow sufficient capturing of the lingual surface of the auricle without distortion. A 0.005mm polyurethane liner was prepared using a vacuum former, and the facial prosthesis was casted above it, custom shaded medical-grade silicone was prepared and injected into the molds. They were then left in the flask compressor to set for 12 hours. Once demolded, the silicone margins were trimmed and thinned to a "feather-edge" to ensure a smooth transition from the silicone to the patient's skin. Further color adjustments were made chairside upon delivery of the prosthesis until satisfactory results were achieved as presented in Figure 3. The main limitation of this technique is in restoring these patients outside hospital institutions, as gaining access to the scans may be limited. Otherwise, exposure to radiation to obtain new scans for the sake of capturing the acquired defect may not be indicated. Another limitation of this technique is that it does not capture sharp patterns or precise details, such as superficial wrinkles.

Clinical Significance

This hybrid workflow leverages existing medical CT scans to fabricate facial prostheses with greater efficiency and precision. Instead of hours of manual sculpting, practitioners/anaplastologists can rapidly replicate the patient's original anatomy using mirrored data for a precise, personalized fit. This head start allows for a reduction in chairside time, and the patient can receive a prosthesis in a shorter time frame. Most importantly, this workflow utilizes free, open-source software that is easily accessible on most modern laptops. Hybrid workflows synergize the precision of digital technology with the artistry of conventional techniques to achieve superior outcomes in facial prosthetics.

Post-treatment Photographs (Figure 3)



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